ESTIMATION OF YUKON RIVER SALMON PASSAGE IN 2001 USING HYDROACOUSTIC METHODOLOGIES

By

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OEO/ADA STATEMENT

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ABSTRACT

The Yukon River sonar project has provided daily passage estimates for chinook salmon *Oncorhynchus tshawytscha*, and summer and fall chum salmon *O. keta* for most years since 1986. During this time, the project has undergone important changes, including a frequency switch from 420 kHz to 120 kHz and a change in aiming strategies from one in which the transducer was aimed at an angle to the current to one that is aimed closer to perpendicular in order to maximize fish detection. Fish passage for each species was estimated in 2001 through a two component process: (1) estimation of total fish passage with 120 kHz single-beam sonar, and (2) estimation of species proportions by sampling with a series of gillnets of different mesh sizes. An estimated 1,402,824 $\pm$ 10,712 (s.e.) fish passed through the sonar sampling area between 12 June and 31 August, 39% along the right bank and 61% along the left bank. Included were an estimated 118,935 $\pm$ 6,646 large chinook salmon (>655 mm long), 18,518 $\pm$ 2,425 small chinook salmon (<655 mm), 394,078 $\pm$ 10,204 summer chum salmon, and 360,356 $\pm$ 13,300 fall chum salmon. Occasional sonar periods were missed due to strong wave action. Passage estimates include estimated data from the missed periods. Routine system analyses did not reveal any problems that might interfere with sampling. Relationships between signal loss and hydrological parameters continued to be explored.

KEY WORDS: salmon, hydroacoustic, escapement, species apportionment, net selectivity.

INTRODUCTION

History

Commercial and subsistence fisheries harvest salmon *Oncorhynchus spp.* over more than 1,600 km of the Yukon River in Alaska and Canada. These salmon fisheries are critical to the way of life and economy of people in dozens of communities along the river, in many instances providing the largest single source of food and/or income.

Management of these fisheries is complex and difficult due to the number, diversity, and geographic range of fish stocks and user groups. Information upon which to base management decisions come from several sources, each of which has unique strengths and weaknesses. Assessments of abundance in tributaries obtained through aerial and foot surveys, mark-recapture, weirs, towers, or sonar techniques provide stock-specific estimates or escapement indices. Most of this information is obtained after the majority of the fisheries have been conducted. Gillnet test fisheries near the river mouth provide in-season indices of run-strength, but interpretation of these data is confounded by gillnet selectivity, changes in net site characteristics, and varying fish migration routes through the multi-channel river mouth. Also, the functional relationship between test-fishery catches and abundance is unknown.

Hydroacoustic estimates of fish passage from this project complement information obtained from other sources. The project uses fixed location, split-beam sonar to estimate daily upstream passage of fish. A series of gillnets with different mesh sizes are drifted through the acoustic sampling areas to apportion the passage estimates to species. The project is located at river km 197 near Pilot Station, far enough upriver to avoid the wide, multiple channels of the Yukon River delta. Because salmon migrate from the river mouth to the sonar site in two to three days, the project provides timely fish abundance information to managers of fisheries downstream of the sonar site. There is only one major spawning tributary (the Andreafsky River) downstream from the sonar site.

The Yukon River sonar project has provided daily passage estimates to fisheries managers for most years since 1986. The project has used hydroacoustic equipment since 1993 that operates at a lower frequency (120 kHz) than formerly (420 kHz), and is capable of detecting fish at longer ranges. In addition, species apportionment methodology has been streamlined, and net selectivity has been estimated more accurately (Fleischman et al. 1995).

Objectives

Project objectives in 2001 were to provide daily and seasonal passage estimates for chinook and chum salmon, estimate the precision of these estimates, and perform routine system analyses to ensure consistent data collection and to provide early detection of problems which might arise. The main challenges faced by the project are to use sonar technology to detect fish migrating past the sonar site and to develop viable methods for estimating the relative abundance of each species detected.

This past season, the project transitioned from older dual-beam systems to newer split-beam equipment. The newer equipment operates at 120 kHz, the same frequency that has been used since 1993, and counts were generated by marking charts by hand. Electronic data were collected to examine the feasibility of using computers to group echoes into fish in the hopes of automating the process in the future.

METHODS

Hydroacoustic Data Acquisition

Equipment

Sonar equipment for the left bank (relative to a downstream perspective) of the Yukon River included: 1) a Hydroacoustics Systems Inc[2] (HTI) Model 244 (SN 1228641) echosounder configured to transmit and receive at 120 kHz; 2) HTI 120 kHz split-beam transducer (SN 1029504) with a 2.8°x10 ° nominal beam width; 3) one 250 m HTI split-beam transducer cable (SN 1228696) connecting sounder to transducer; 4) a Hydroacoustic Technology, Inc. (H.T.I.) Model 405 digital chart recorder coupled with a Panasonic KXP 3624 dot matrix printer; and 5) a Hewlett-Packard Model 54501A digital storage oscilloscope. On 15 July echosounder 1228641 was replaced with spare echosounder 1301449 due to an equipment failure.

Right-bank sonar equipment included: 1) a HTI Model 244 (SN 1301448) echosounder configured to operate at 120 kHz; 2) an HTI split-beam 120 kHz transducer (SN 1301549) with a 6°x10° nominal beam width; 3) three 250 m (228.6 m combined length) HTI split-beam cable (SN's 1228689, 90 and 91) connecting the sounder to the transducer; 4) H.T.I. Model 405 digital chart recorder coupled with Panasonic KXP 3624 dot matrix printer; and 5) a Hewlett-Packard

[2] Mention of a company's name does not constitute endorsement by ADF&G.

Model 54501A digital storage oscilloscope. Transducer SN 1301549 was replaced with transducer SN 1405205 on 24 August due to an equipment failure.

Each sounder/transducer/cable configuration was calibrated prior to the field season (Table 1). Split-beam data were digitized, processed, and electronically stored with a Biosonics Model 281 echo signal processor (ESP) installed in a Compaq 386 20e personal computer.

Transducers were mounted on metal tripods and remotely aimed with HTI model 662H dual-axis rotators. Rotator movements were controlled with HTI model 660-2 rotator controllers with position feedback to the nearest 0.1°. Gasoline generators (3500 W) supplied 120 VAC power.

Sampling Procedures

We deployed a single transducer on the left (south) bank and right bank at a point where the river is approximately 1,000 m wide (Figure 1). The right bank has a stable, rocky bottom that drops off steeply to the thalweg (Figure 2) with a vertical angle of 8.4° calculated from a depth of 23.2 m at a range of 157 m. We positioned the right-bank transducer 5-10 m from shore, adjusting the aim between two strata (0-40 m) and (40-130 m) to position the beam as close to the river bottom as possible for each sample.

The left-bank river bottom drops off gradually with a vertical angle of 3.2°, calculated from a depth of 15.6 m at 277.7 m, with a slightly steeper slope nearshore, 5.5° calculated from a depth of 5.3 m at 54 m (Figure 3). A single transducer was deployed nearshore approximately 10 m from shore utilizing three aims to sample a nearshore stratum (0-50 m), a midshore stratum (50-150 m), and an offshore stratum (150-245 m). The transducer was repositioned frequently to compensate for the dynamic water level.

Each acoustic sampling stratum was subdivided into five equal range sectors. Sample data were tallied by sector in 15-minute intervals during daily sampling periods from 0530 to 0830, 1330 to 1630, and 2130 to 0030 alternating every hour between strata.

We counted echoes as fish if at least one ping in the cluster passed the second printer threshold level (see Equipment Settings, Thresholds, Data Storage) and the targets did not resemble inert downstream objects. Multiple fish tracings were marked if there was a discontinuity in the tracing and the second mark indicated movement in a direction different from the first. Fish tracings were tallied on field data forms, then entered into an R:Base database. The data were checked daily for data entry or tallying errors, then processed using commercial statistical data processing (SAS) software.

All personnel were trained to distinguish between fish tracings and non-target echoes. Chart printouts were reviewed daily by either the project leader or crew leader to check the accuracy of the marked fish tracings and reduce individual biases. Each chart image was checked for indications of signal loss and changes in bottom reverberation markings which might indicate either a movement of the transducer or a change in bottom structure.

We sampled continuously for 24 hours on 26 June, 11 and 24 July, and 8 and 21 August to estimate uncertainty associated with the normal sonar sampling schedule. Sampling was divided among sampling strata in proportions consistent with the regular sampling schedule.

Equipment Settings, Thresholds, Data Storage

We used a 40 log(R) time-varied gain (TVG) and 0.4 ms transmit pulse duration during all sampling activities. The receiver bandwidth was automatically determined by the equipment based on the transmit pulse duration. Pulse repetition rates were set below the maximum allowed by range to avoid overloading printer buffers. On the left bank, the nearshore strata pulse repetition rate was set to 4 pings per second (pps), the midshore strata was set at 3 pps and the offshore strata was set at 2.5 pps. The puse repetition rate for the right bank nearshore was set at 5 pps and the offshore strata was set at 3 pps.

All sampling was conducted using elliptical dual beam transducers operating in single beam mode. On the right bank, a ten degree circular transducer was initially deployed but was changed to a 6°x10° elliptical transducer to reduce surface reverberation. The left bank was sampled using a 2.8°x10° elliptical transducer. We briefly deployed a 1.5°x10° elliptical transducer but found the narrower beam did not produce charts that were any "cleaner" than the wider beam. For this reason, it was decided that the project would continue using one transducer (2.8°x10°) to simplify operations.

Echoes were digitized by chart recorders, then printed on wide carriage, continuous-feed paper using dot matrix printers. Four printer thresholds corresponding to degrees of gray-line were set for all strata in approximately 3 dB increments. Initially, the lowest sampling threshold, set at –48 dB, was approximately 17 dB lower than the theoretical on-axis target strength of a chum salmon of minimal length (450 mm), calculated using Love's equation (Love 1977). Lowering the threshold by 17 dB allows for detection across the nominal beam width (6 dB) and variability (~11 dB) induced by fish aspect and noise corruption. Left bank thresholds were adjusted frequently to compensate for environmentally induced signal loss by reducing the threshold to a level where bottom reflections were again detectable across the strata's range (Figure 5). On the right bank, the majority of sampling was conducted at a threshold of –45 dB. On occasion, this threshold was raised to eliminate unwanted noise, or lowered to compensate for loss associated with wave action. Threshold levels (in mV) were recorded and converted to target strength, TS_{dB}, as follows:

$$TS_{dB} = 20 \bullet \log\left(\frac{T_{mV}}{1000mV}\right) - \left(SL + G_S + G_R\right) \quad \textbf{(1)}$$

where

T_{mV} = chart recorder threshold in mV,
SL = transmitted source level in dB,
G_S = through-system gain,
G_R = receiver gain.

Aiming

The transducer was always aimed to maximize fish detection. Horizontally, the beam was oriented along the best bottom profile approximately perpendicular to fish movement so the majority of fish would present the largest possible reflective surface. Since most fish travel close to the substrate, the maximum response angle of the beam was oriented along the river bottom through as much of the range as possible.

Fluctuating water level required frequent repositioning and subsequent re-aiming of the transducer beam. The left-bank transducers were re-aimed more often to compensate for the dynamic bottom conditions on that side of the river. Rotator settings for each new aim were documented and chart printouts of the new aim were marked and dated. Because rotator position displays are only accurate to about 0.3 degrees, returning to the same rotator settings did not guarantee a return to the same aim. All personnel were trained to first reaim to established pan and tilt settings, then refine that aim to match bottom striations on the current chart printout with those of displayed chart samples when changing between sampling strata, and to notify a supervisor if an acceptably close chart image match could not be re-established.

System Analyses

The hydroacoustic system was routinely analyzed following procedures first established in 1995 (Maxwell et al. 1997). System analyses included equipment performance checks, bottom profiles using down-looking sonar, and hydrologic measurements.

Hydroacoustic Equipment Checks

Some of the equipment diagnostics that have traditionally been done, were not performed this year due to the change in sonar equipment. Some of the traditional diagnostics are now unnecessary such as checking the TVG amplification. In the new system, most of the signal processing is performed digitally as opposed to the analog signal processing used in the older equipment. The digital circuits, unlike the analog, will not drift over time. In addition, the dummy loads, which are specific to the equipment, were not available to check sounder output or signal loss through the cables. These will need to be custom built for the project if this diagnostic is to be performed in the future. These dummy loads are not necessary in the short term because we have spare cables in the event of damage. Long term, it would be a good ideal to look into purchasing dummy loads to veryify cable performance after repairs.

To verify that the sonar system was operating normally, we measured the *in situ* target strength of a 76.2 mm stainless steel sphere (nominal target strength at 120 kHz about –28 dB). The target was suspended from the side of a skiff anchored offshore. We aimed the beam at the suspended target, maximizing the echo amplitude in both the horizontal and vertical planes. The minimum threshold was set just above the noise floor. Target data were imported into an Excel spreadsheet for analysis. During post-processing, the target data were isolated from extraneous echoes by manually selecting only echoes belonging to the target.

Bottom Profiles

Bottom profiles were recorded along both banks using a Lowrance X-15 fathometer (192 kHz) with a 20 degree conical beam to locate deployment sites with suitable linear bottom profiles. Inseason, the fathometer was used regularly to monitor changing bottom conditions and to watch for the formation of sandbars capable of re-routing fish to unensonified areas. Aquacoustics Inc. was contracted early in the season to create a bathymetric map of the sampling area (Figure 4) prior to sonar deployment to document bottom conditions and sandbar formation.

Hydrologic Measurements

Hydrological measurements were recorded daily. Water level was measured using a staff gauge located offshore from the field camp. The water level measurements were adjusted to the United States Geological Survey Water Resources Division reference located approximately 500 m downstream of Pilot Station to allow comparison of water levels from previous years. Conductivity, water temperature, and secchi disk measurements were collected daily offshore along both banks.

Reverberation Measurements

Starting July 25, daily reverberation measurements were made by tilting the transducer up about 3-4 degrees and collecting an ensemble average of root mean square (rms) voltages over 100 pings. The goal was to attempt to directly measure the attenuation coefficient by fitting the model of Dahl. et.al. 2000(page 7) to the measured reverberation.

The volume reverberation level (*RL*) was calculated from the averaged rms voltages by the formula:

$$RL=20\log_{10}(V_{rms})-G_R-G_S \qquad \textbf{(2)}$$

where V_{rms} is the root mean squared voltage, G_R is the receiver gain and G_S is the through system gain.

Species Composition Data Acquisition

Equipment and Procedures

Gillnets were drifted in three zones (right bank, left-bank nearshore, and left-bank offshore) within corresponding sonar sampling areas to estimate species composition. Eight mesh sizes were fished to effectively capture all size classes of fish present and detectable by the hydroacoustic equipment. During the summer season (prior to 19 July), gillnets of mesh sizes 216 mm (8.5 in), 43 meshes deep (MD); 191 mm (7.5 in), 48 MD; 165 mm (6.5 in), 55 MD; 133 mm (5.25 in), 69 MD; 102 mm (4 in), 90 MD; and 70 mm (2.75 in), 131 MD, were used. The 216 mm (8.5 in) and 133 mm (5.25 in), were discontinued starting 19 July. At this time the following nets were added, 146 mm (5.75 in), 63 MD and 127 mm (5.0 in), 72 MD. All nets were 45.7 m (25 fathoms, 52.5 stretch fathoms) long and 7.6 m (25 ft) deep. Nets were constructed of Momoi MTC-50 or MT-50, shade 11 or 3, double knot multifilament nylon twine and hung using a 2:1 hanging ratio.

Gillnetting took place between sonar periods twice daily from 0915 to 1215 and 1715 to 2015. During each gillnet sampling period four nets were drifted within each of three zones, one on the right bank and two on the left bank, for a total of 24 drifts per day. The shoreward end of the left-bank nearshore drift was approximately 5 to 10 m from shore. The left-bank offshore drift originated further offshore (approximately 70 m) so as not to overlap with the nearshore drift. All drifts with one net were completed before switching to the next net. The two left-bank drifts with a given net were not done consecutively (i.e., drifts were done on alternate banks: left-right-left), so that there was a minimum of 20 minutes between the drifts on the same bank.

Four times were recorded to the nearest second onto field data sheets for each drift: net start out (SO), net full out (FO), net start in (SI), and net full in (FI). Fishing time (t), in minutes, for each drift was approximated as

$$t = SI - FO + \frac{FO - SO}{2} + \frac{FI - SI}{2}. \tag{3}$$

Drifts were generally eight minutes in duration, but were shortened when necessary to avoid snags and limit catches during times of high fish passage.

Captured fish were identified to species and measured to the nearest 5 mm length. Salmon species were measured from mid-eye to fork of tail; non-salmon species were measured from snout to fork of tail. Fish species, length and sex were entered onto field data sheets. Each drift record included the date, fishing time, sampling period, mesh size, length of net, and captain's initials. Scale samples were collected from chinook salmon, mounted on scale cards, and referenced to test-fishing data sheets. Data were transferred from field data sheets into an R:Base database and processed using SAS software. Scale data will be processed and reported separately.

Prior to 1999, any chinook salmon that was less than 700 mm in length was called a "jack." This length was originally calculated as the average length of a chinook salmon under 10 lbs (Tracy Lingnau, ADF&G, Anchorage, personal communication). In 1999, this length was changed when analysis of age and length data collected from 1993 through 1998 produced an average length of 655 mm separating four and five year old chinook salmon (Pfisterer and Maxwell 2000).

Genetic sampling of chum salmon occurred from 29 June through 6 August. Captured chum salmon were marked using numbered floy tags to allow association of age, sex, length and genetic data. Thirty fish were selected at random following each fishing period. Heart, liver and muscle tissues were extracted from the selected chum salmon, placed in numbered cryotubes, then frozen in liquid nitrogen. Analysis of these data will be done by the ADF&G genetics laboratory.

Captured fish were distributed to local villagers whenever possible. Fish dispersal was documented daily.

Species Proportions

Species proportions were estimated from relative gillnet sampling catch-per-unit-effort (CPUE) data, after first adjusting for gillnet size-selectivity. Separate gillnet selectivity curves (Maxwell 2000) were used for chinook salmon, summer run chum salmon, fall run chum salmon, coho salmon (*O. kisutch*), pink salmon *(O. gorbuscha)*, whitefish *(Coregonus spp.)*, cisco *(C. sardinella, C. laurettae)*, and a combined group of all other species.

Analytical Methods

Fish Passage

Daily fish passage was estimated by summing the counts over all sectors, converting this number to an hourly passage rate, averaging the passage rate from each sampling period, and expanding the final count temporally to obtain the daily estimate. Total daily passage was estimated separately for each zone. Zone 1 consisted of the entire counting range on the right bank, corresponding to strata 1 and 2. Zone 2 consisted of the counting range from 0 to 50 m on the left bank, corresponding to stratum 3. Zone 3 consisted of the counting range from 50 to 350 m, corresponding to strata 4 and 5.

Total fish (y) passing through stratum s of zone z during sample q of sonar period p of day d was calculated by summing net upstream targets over all sectors c,

$$y_{dzpsq} = \sum_{c} y_{dzpsqc}. \qquad \textbf{(4)}$$

The passage rate (r) in fish per hour, for stratum s of zone z during sonar period p of day d, was computed as

$$r_{dzps} = \frac{\sum_{q} y_{dzpsq}}{\sum_{q} h_{dzpsq}}, \quad \textbf{(5)}$$

where h_{dzpsq} is the duration, in hours, of sample q of sonar period p of day d for stratum s of zone z. The passage rate for zone z during sonar period p of day d was computed as the sum of passage rates for strata associated with each zone,

$$r_{dzp} = \sum_{s} r_{dzps} \,. \quad \textbf{(6)}$$

The passage rate for zone z during day d was estimated by the average sonar period passage rate,

$$\hat{r}_{dz} = \frac{\sum_{p} r_{dzp}}{n_{sdz}}, \quad \textbf{(7)}$$

where n_{sdz} is the number of sonar periods during day d on zone z. Finally, the total passage of fish in zone z during day d was estimated as

$$\hat{y}_{dz} = 24\, \hat{r}_{dz} \,. \quad \textbf{(8)}$$

Sonar sampling periods, each three hours in duration, were spaced at regular (systematic) intervals of eight hours. Treating the systematically sampled sonar counts as a simple random sample would yield an over-estimate the variance of the total, since sonar counts were highly autocorrelated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations, recommended by Brannian (1986) and modified from Wolter (1985), was employed;

$$\hat{V}ar(\hat{y}_{dz}) = 24^2 \frac{1 - f_{dz}}{n_{Sdz}} \frac{\sum_{p=2}^{n_{Sdz}} (\hat{r}_{dzp} - \hat{r}_{dz,p-1})^2}{2(n_{Sdz} - 1)}, \quad \textbf{(9)}$$

where f_{dz} denotes the first-stage sampling fraction, 8 hrs/24 hrs = 0.33.

Missing Data

Equipment malfunctions and other uncontrollable events occasionally result in missing sonar data. When individual subsamples within a sonar period were missed, fish passage was estimated based on existing subsamples for that period. If a portion of a subsample was missed, fish passage was estimated from the remaining sample providing the sample contained at least five of the fifteen minutes. Data missing from a single stratum for an entire period or more was estimated from data obtained from period(s) sampled during the same day.

Species Composition

Total effort (e), in fathom-hours, of drift j with mesh size m during gillnet sampling period f in zone z on day d was calculated as

$$e_{dzfm} = \frac{25\,t_{dzfm}}{60} \tag{10}$$

since all nets were 45.7 m (25 fathoms) long.

The proportion (p) of species i during test-fishing period f in zone z on day d was then estimated by the ratio of the sum of the catch of all lengths of species i to the sum of the product of the gillnet selectivity and effort (e) to the total of the same quantity summed over all species, i.e.,

$$\hat{p}_{idzf} = \frac{\dfrac{\sum_m c_{ildzfm}}{\sum_m s_{ilm}\, e_{dzfm}}}{\sum_i \sum_l \left(\dfrac{\sum_m c_{ildzfm}}{\sum_m s_{ilm}\, e_{dzfm}} \right)}. \tag{11}$$

For zone z on day d, the proportion of species i was estimated as

$$\hat{p}_{idz} = \frac{\dfrac{\sum_f \sum_m c_{ildzfm}}{\sum_f \sum_m s_{ilm}\, e_{dzfm}}}{\sum_i \sum_l \left(\dfrac{\sum_f \sum_m c_{ildzfm}}{\sum_f \sum_m s_{ilm}\, e_{dzfm}} \right)}. \tag{12}$$

The estimator of the variance of p_{idz}

$$\hat{V}(p_{idz}) = \frac{1}{n_{Tdz}} \frac{\sum_f (\hat{p}_{idz} - \hat{p}_{idzf})^2}{n_{Tdz} - 1} \tag{13}$$

where: n_{Tdz}=number of gillnet sampling periods in zone z during day d.

Fish Passage by Species

The passage of species *i* in zone *z* during day *d* was estimated by

$$\hat{y}_{idz} = \hat{y}_{dz} \bullet \hat{p}_{idz}. \tag{14}$$

Finally, passage estimates were summed over all zones and all days to obtain a seasonal estimate for species $Y_{i.}$

$$\hat{Y}_i = \sum_d \sum_z \hat{y}_{idz} \cdot \tag{15}$$

Except for the timing of sonar and gillnet sampling periods, sonar-derived estimates of total fish passage were independent of gillnet-derived estimates of species proportions. Therefore the variance of their product (daily species passage estimates y_{idz}) was estimated as the variance of the product of two independent random variables (Goodman 1960),

$$\hat{V}ar(\hat{y}_{idz}) = \hat{y}^2_{dz}\hat{V}ar(\hat{p}_{idz}) + \hat{p}^2_{idz}\hat{V}ar(\hat{y}_{dz}) - \hat{V}ar(\hat{y}_{dz})\hat{V}ar(\hat{p}_{idz}) . \tag{16}$$

Finally, passage estimates (equation 15) are assumed independent between zones and among days, so the variance of their sum (equation 16) was estimated by the sum of their variances,

$$\hat{V}ar(\hat{Y}_i) = \sum_d \sum_z \hat{V}ar(\hat{y}_{idz}) . \tag{17}$$

Assuming normally distributed errors, 90% confidence intervals were calculated as

$$\hat{Y}_i \pm 1.645\sqrt{\hat{V}ar(\hat{Y}_i)}. \tag{18}$$

SAS program code (Rich, 2000) was used to calculate passage estimates and estimates of variance.

Missing Data
Equipment malfunctions occasionally conflict with gillnet sampling. When insufficient gillnet sampling data are available for a given day, the data are pooled with data from an adjacent day with adequate data, and the pooled data are then applied to the corresponding days of sonar passage estimates.

RESULTS

The Yukon River sonar project operated from 11 June through 31 August in 2001. Although the range-dependent signal loss observed in previous years (Rich 2001; Pfisterer and Maxwell 2000) was not a serious problem in 2001, there were other difficulties encountered this past season. These problems were primarily associated with the abnormally high water levels and were, for the most part, limited to the south bank. Early in the season there was a reverberation band present on the south bank that was located about 15 to 25 meters from shore. This band partially obscured fish passing within this zone. We believe this band is caused by sediment eroding from the bank just upstream of the sonar site – unfortunately there is nothing we can do to correct this problem. Additionally, the late breakup left a very rough bottom on the south bank that we suspect may have compromised counts. Within one to two weeks the bottom smoothed out alleviating this concern (Figure 3). Due to these problems, we believe our counts early in the season were conservative.

To better estimate the number of fish that passed during the first few weeks, we compared the north and south bank counts over days we felt the counts were accurate and used this relationship to estimate the south bank passage. We believe the passage estimates produced from this relationship more accurately reflect the true run and are the numbers presented in this report. Infrequently, sonar data were unobtainable due to wave action, which caused the signal to fade in periodic intervals. The missing data were estimated by averaging the hourly passage rates for sonar data collected during periods before and after the missing period(s). Passage estimates were transmitted to fishery managers in Emmonak daily.

Test-Fishing

A total of 7,240 fish were captured during 1,928 drifts totaling 13,768 minutes. The catch consisted of 2,227 summer chum salmon, 1,961 fall chum salmon, 579 large chinook salmon (655 mm length or greater), 94 "jack" chinook salmon, 1,192 coho salmon, 9 pink salmon, 429 whitefish, 565 cisco, and 184 fish of other species (Tables 2 and 3). Data from missed or partial gillnet sampling periods were pooled with those from an adjacent day to estimate species proportions. When the day's total capture in a single zone was less than four, the reporting period was extended by including data from an adjacent day whose data (both passage rate and species composition) appeared most similar. In 2001, reporting periods longer than one day were used on 17 occasions.

Hydroacoustic Estimates

An estimated 1,402,824 ± 10,712 (s.e.) fish passed through the sonar beams during the 2001 field season; 541,513 ± 5,889 (39 %) along the right bank, 616,773 ± 7,690 (44 %) along the left bank nearshore, and 244,538 ± 4,563 (17 %) along the left bank midshore and offshore. Tables 4 and 5 provide daily records of passage estimates by zone, standard errors, and the total passage coefficients of variation.

Chum salmon were the most abundant species during both summer and fall seasons (Figure 6). Chum salmon passage estimates totaled 754,434 with 394,078 ± 16,786 (90 percent confidence) passing the sonar site during the summer season from 12 June through 18 July and 360,356 ± 21,879 passing during the fall season from 19 July through 31 August (Table 6). Chinook salmon passage estimates were composed of 118,935 ± 11,472 fish greater than 655 mm in length, and 18,518 ± 3,990 "jacks" shorter than 655 mm. Coho salmon passage estimates reached 143,213 ± 14,883, although this estimate likely does not include the entire run. Other species, totaling 372,606 ± 23,922 fish, included pink salmon, cisco, whitefish, inconnu (*Stenodus leucichthys*), burbot (*Lota lota*), sucker (*Catostomus catostomus*), Dolly Varden (*Salvelinus malma*), sockeye salmon (*Oncorhynchus nerka*), and northern pike (*Esox lucius*). Daily passage estimates by species for the summer and fall seasons are listed in Tables 7 and 8.

The passage estimate for summer chum was very similar to the 2000 estimate. The fall chum passage estimate was close to the value estimated in 1999 (Figures 7). Chinook salmon estimates were only slightly higher than 1998 but were nearly twice the number estimated in 2000 (Figure 8). The overall coho salmon estimate was similar to that of 1998, however, the project ended earlier in 2001. Over the period of time the project ran in 2001, the cumulative coho passage tracked most similar to 2000 (Figure 8).

The summer chum salmon run started at about the same time as in 2000 with 25% of the 2001 run occurring by 24 June, about 4 days later than in 1997 or 1995 (both 20 June). About 75% of the 2001 run passed through by 5 July compared to 7 July 2000, 4 July 1999, 9 July 1998, 5 July 1997 and 3 July 1995 (Figure 9). Twenty-five percent of the fall season chum salmon run passed the sonar site by 22 July, the earliest of any year from 1995 to present with the majority of the run (75%) passing by 10 August (Figure 9).

Twenty-five percent of the chinook salmon run occurred by 21 June, about the same time as in 2000. The majority of the chinook salmon (75%) passed the sonar site by 3 July, similar to 1999 and 2000 but about 8 days later than 1997 or 1995 (Figure 10). The last chinook salmon captured in 2001 was on 31 August.

Seasonal passage estimates and CPUE for the left bank nearshore and right bank for both summer and fall seasons were significantly correlated (Figures 11 and 12). The correlation coefficients for the summer season were $R=0.884$ for right bank, $R=0.823$ for left bank nearshore (each with $p<0.0001$) and $R=0.085$ for left bank offshore. For the fall season the correlation coefficients were R=0.768 for right bank, R=0.821 for left bank nearshore (each with $p<0.0001$), and R=0.309 for left bank offshore.

The summer and fall passage was plotted as a percentage in 20 m range increments by bank and season for 1995 through 1999 to illustrate the horizontal distribution of fish in the sampling area (Figures 13 and 14). Passage levels declined sharply as a function of the distance offshore. On the left bank, 90% of the detected passage during the 2001 summer and fall seasons occurred within 90 m from the transducer compared to 110 m in 2000, 110 m in 1999, 130 m in 1998, 150 m in 1997, and 190 m in 1995. On the right-bank, 90% of the detected passage occurred within 50 m of the right-bank transducer in 2001 and within 70 m in the years 1995 through 2000.

System Analyses

Passage estimates based on five 24-hour sampling periods were 1.7% smaller than routine nine hour sampling during these same days (Table 9). Individual days varied from 7.79% fewer fish estimated during the 24-four hour sampling on 20 July to 5.77% more fish estimated on 6 August.

Bottom profiles conducted along the right bank at the transducer location revealed a smoothly sloping area suitable for sonar deployment (Figure 2). No changes were noted in the steeply sloping, rocky bottom along the right bank during the field season. Transects recorded along the left bank were very rough in the early season making it difficult to choose a suitable sonar deployment location. Over the course of the season, the depressions in the left bank appeared to fill in and smooth out the left bank profile (Figure 3).

Two sandbars, observed in prior field seasons (Maxwell et al. 1997; Maxwell and Huttunen 1998, Pfisterer and Maxwell 2000), were also detected in 2001. The Atchuelinguk Bar (Figure 4) extended downstream along the right bank from the confluence of the Atchuelinguk and Yukon Rivers to slightly downstream of the First Slough entrance, well upstream of the sampling area. The mid-river sandbar extended from the river bend downstream past the left-bank sampling area approaching to within 250 m of the right bank's sampling area.

The Yukon River water level was rising when we arrived at the Pilot Station field camp. Water level varied considerably throughout the season (Figure 15) with local maxima occurring on 27 June (8.61 m), 10 August (6.50 m) and 30 August (6.56 m) and local minima occurring on 1 August (5.98 m) and 22 August (6.09 m). Compared with previous years (1995 through 2000), the water level was consistently higher in 2001.

Conductivity on the left bank rose slowly during the field season (Figure 16) ranging from 136.1-229.1 μS. Conductivity on the right bank generally increased throughout the season but fluctuated on a daily basis more than was observed on the left bank. Right bank conductivity measurements ranged between 136.1 and 221.3 μS. Daily fluctuations in right bank conductivity measures appear to be more a result of sampling location rather then temporal differences. Unlike 1998, a comparison of water level and conductivity demonstrated no significant relationship for either bank. Offshore from the left bank, secchi disk measurements varied from 3 to 13 cm below the surface with an average visibility of 7 cm. Secchi disk visibility ranged from 4 to 40 cm off the right bank with an average visibility of 13 cm. Right bank secchi disk visibility remained higher throughout most of the field season compared to the left bank (Figure 17). Daily water temperatures ranged from 10 to 18 °C and averaged 14 °C (Figure 18).

Split-beam target strength estimates using a 76.2 mm (3") stainless steel sphere were collected on the left bank on two separate occasions; 20 June and 24 July. On each day, target strength data were collected at three different ranges (Figure 19). On 20 June data were collected at 11 m (two files, mean target strength values of –27.5 dB and –30.6 dB), 30 m (average target strength of -32.9 dB) and 50 m (average target strength of -36.8 dB). On 24 July data were collected at 8 m (average target strength of –27.1 dB), 25 m (average target strength of –31.3 dB) and 75 m (average target strength of –34 dB).

A reverberation band appeared briefly in the left bank nearshore strata this season. As has been observed in prior years (Maxwell and Huttunen, 1998; Maxwell, 2000), the reverberation band was wide enough to obscure fish migrating nearshore. By 1 July, the reverberation band was much reduced in strength and no longer appeared to affect our ability to detect fish.

As in 1999 and 1998, range-dependent signal loss was observed, although to a lesser degree, on the left bank during the 2001 field season. Signal loss was detected by the decrease in signal amplitude reflected from the bottom structure and in target strength measurements recorded at multiple ranges. There was no apparent range-dependent signal loss observed on the right bank, however, the maximum range on the right bank was less than 150 m.

The relationship between signal loss (threshold used in the outermost stratum) and secchi depth (Figure 20) was not as strong as observed in 1999 (Pfisterer and Maxwell, 2000). Unfortunately, turbidity was not measured by Hokkaido University this past summer and we were not able to make this comparison.

Except for temperature, the reverberation measurements did not show a strong relationship to the environmental variables measured at the site (Figure 21). In addition, neither the reverberation level nor alpha level demonstrated any relationship to threshold levels. There does, however, appear to be a positive relationship between temperature and alpha.

DISCUSSION

Yukon River sonar passage estimates for 2001 were in agreement with many of the other salmon assessment projects in the drainage. As in 1999 and 2000, the horizontal distribution of detected fish was close to shore in 2001 (Figures 13 and 14). Horizontal distribution is probably due to a combination of factors such as fish passage rate, species composition and water level. The relatively low fish passage this year combined with the extremely high water level may help explain the close distribution of fish to the shore. The sharp decline in fish passage with increasing range suggests that most fish pass within the ensonified range. Although detectability is also a function of range and may account for some of the decline, we believe the vast majority of all salmon pass through the ensonified regions of the river.

CPUE and passage estimates at the project correlated well in the right bank and left bank nearshore strata during both the summer and fall seasons (Figures 11 and 12). The correlation between CPUE and passage was very poor in the left bank offshore stratum. This is likely due to the very low catches in this range which often necessitated pooling counts across many days into report periods which would result in report periods with relatively high passages but low CPUEs.

The 24-hour sonar estimates compared favorably with the normal nine hour estimates. Of the four days in which 24-hour samples were collected, the 24-hour estimates were higher on two days and lower on two. Based on this small sample size, it appears that the normal sampling routine is adequate to assess fish passage at this site. Also, comparisons made in previous years have yielded similar observations (Rich 2001; Pfisterer and Maxwell 2000; Maxwell 2000; Maxwell and Huttunen 1998; Maxwell et al., 1997).

Two sandbars observed in past years were present this field season. The Atchuelinguk sandbar remained far upstream of the sampling region. Downward progression of this sandbar is unlikely due to its proximity to the cutbank on the Yukon River and the confluence of First Slough and the Yukon River downstream of the bar. The mid-river sandbar does not appear to have extended much since the 1999 field season. In 2001, the side-edge of the sandbar was charted about 350 m offshore from the left bank transducer (compared to 350m in 1999 and 500 m in 1998). The most downstream extension of this sandbar was observed slightly upstream of the right bank transducer (similar to 1999) at a depth of about 13 m (~43 ft).

Right bank bottom profiles were similar to prior years with little or no change throughout the season. Upon arrival, the left bank profiles were very rough and non-linear. As the season progressed, the holes filled in with sediment and the profiles then resembled those recorded in previous years. Suitable profiles for sonar assessment were found on both sides of the river, although it wasn't until 1 July that we were comfortable with the left bank site.

Signal loss, as determined from the threshold needed to detect bottom at the outermost range, varied throughout the season but did not appear to affect detectability as significantly as in 1999 (Pfisterer and Maxwell, 2000). Comparisons of signal loss to hydrological measurements did not show the high correlations that were observed in 1999. Target strength data that were collected suggest the signal loss at the site is well in excess of what would be expected for freshwater. Although these target strength measurements appear less variable than measurements taken previously with dual-beam equipment, the process is time consuming, making it difficult to obtain a measure of signal loss on a frequent basis without considerably disrupting normal data collection.

Directly obtaining the attenuation coefficient through volume reverberation measurements would be a potential solution, but the data collected this past season did not appear to correlate well with environmental variables or to agree with the attenuation measured using the standard target (Figure 20). Somewhat confounding is the positive relationship between alpha and temperature. Theory would suggest that the lower temperatures would lead to the higher alpha values (MacLennan and Simmonds, page 22, 1992). One possible explanation for the poor relationships may be inconsistent aims relative to the surface and bottom. This inconsistency would be due to moving the pod in response to changing water levels. The discrepancy and the lack of a correlation to the other environmental variables should be further explored so that this measure will be of use in the future.

Although the range-dependent signal loss observed in previous years was not a serious problem in 2001, there were other difficulties encountered this past season. These problems were primarily associated with the abnormally high water levels and were, for the most part, limited to the south bank. Even though the problems were not persistent throughout the season, they did necessitate adjusting the left bank passage estimates for the first three weeks of the summer season (done by extrapolating left bank counts using right bank counts). We believe this adjusted number is a more accurate reflection of the true passage during this time period.

Split-beam sonar equipment was deployed at the Yukon River sonar project for the first time this past season. The equipment was operated in a single-beam mode to generate daily passage estimates, although split-beam data were collected for future analysis. This phase of the transition went very smoothly and technicians adapted to the new equipment with very little additional training. Future work will focus on developing the ability to have a computer automatically track the split-beam data and generate daily counts. This would remove much of the subjectivity in manually counting the tracks and should at the same time reduce the manpower required to analyze the data.

Estimating fish passage in the Yukon River continues to present major technical and logistic challenges. The sampling environment is often demanding due to the extremely dynamic nature of the water level, turbidity, bottom substrate, and range-dependent signal loss. The hydroacoustic system that we employ in the Yukon River appears to work well for the purpose of detecting passing salmon. We were able to compensate for identified signal loss throughout the field season by modifying equipment parameters in response to the frequent environmental changes. At this point, the system changes are largely subjective and thus hard to objectively quantify as to absolute detectability. Successful estimation of fish passage depends upon constant attention to the frequent changes and diligent re-checking of every part of the acoustic and environmental system.

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Table 1. Pre-season Yukon River sonar equipment calibration data, 2001.

Sounder	Cable Length (m)	Transducer	G1 20LogR (dB)	G1 40LogR(dB)	SL 24 dB	SL 27 dB	SL 30 dB	SL 33 dB	Beam Width
1228641	152.4	1029504	-139.67	-160.76	218.19	221	225.06	227.56	2.8x10
1301449	152.4	1029504	-139.68	-160.62	218.19	221	225.37	228.18	2.8X10
1301448	228.6	1301549	-140.09	-161	213.25	216	220.68	221.62	6x10
1301448	228.6	1301548	-134.84	-155.66	210.75	213.57	217.88	218.81	10x10

Table 2. Summary of daily testfishing catches by species from 11 June to 18 July for the Yukon River sonar project, 2001.

Date	Drift Time Minutes	Chinook >=655mm	Chinook <655mm	Summer Chum	Coho	Pink	Whitefish Species	Cisco	Other Species	Total Catch
06/11/01	224.09	14	0	0	0	0	1	3	22	40
06/12/01	207.29	9	2	0	0	0	1	3	18	33
06/13/01	216.38	13	1	1	0	0	0	0	4	19
06/14/01	216.17	9	1	1	0	0	2	0	1	14
06/15/01	197.65	15	1	3	0	0	0	1	6	26
06/16/01	210.17	40	13	16	0	0	0	3	2	74
06/17/01	74.11	7	0	6	0	0	0	0	0	13
06/18/01	164.21	20	1	68	0	0	1	1	5	96
06/19/01	173.21	39	4	142	0	0	1	1	3	190
06/20/01	157.85	26	4	91	0	0	0	2	0	123
06/21/01	163.93	12	1	82	0	0	0	2	2	99
06/22/01	179.46	17	6	125	0	0	1	1	0	150
06/23/01	182.12	28	3	73	0	0	0	0	0	104
06/24/01	168.59	17	1	57	0	0	0	2	0	77
06/25/01	191.42	15	5	100	0	0	1	1	1	123
06/26/01	166.74	45	5	109	0	0	2	0	1	162
06/27/01	142.07	33	8	143	0	0	0	2	1	187
06/28/01	131.65	21	3	108	0	0	1	2	0	135
06/29/01	150.3	29	5	129	0	0	1	0	1	165
06/30/01	141.4	17	2	81	0	0	0	3	0	103
07/01/01	141.37	21	3	114	0	0	0	3	0	141
07/02/01	149.6	13	5	91	0	0	0	3	5	117
07/03/01	138.3	16	3	63	0	0	1	0	0	83
07/04/01	157.85	18	1	73	0	0	0	2	2	96
07/05/01	150.76	12	1	52	0	0	0	0	1	66
07/06/01	179.71	11	3	41	0	0	0	2	3	60
07/07/01	178.46	10	2	65	0	0	3	2	2	84
07/08/01	167.42	12	1	95	0	0	0	0	1	109
07/09/01	161.77	7	1	77	0	0	0	2	1	88
07/10/01	164.82	4	2	67	0	0	2	2	2	79
07/11/01	168.77	6	0	53	0	0	2	2	3	66
07/12/01	140.63	4	1	22	0	0	2	6	1	36
07/13/01	175.04	1	2	19	0	0	0	10	2	34
07/14/01	154.51	4	1	16	0	0	1	7	3	32
07/15/01	176.19	0	0	9	0	0	0	3	0	12
07/16/01	175.6	3	0	5	0	0	0	2	1	11
07/17/01	183.89	1	0	12	0	1	3	1	6	24
07/18/01	193.22	2	0	18	0	0	2	1	3	26
Summer Totals	6416.72	571	92	2227	0	1	28	75	103	3097

Table 3. Summary of daily testfishing catches by species from 19 July to 31 August for the Yukon River sonar project, 2001.

Date	Drift Time Minutes	Chinook >=655mm	Chinook <655mm	Fall Chum	Coho	Pink	Whitefish Species	Cisco	Other Species	Total Catch
07/19/01	166.70	0	0	119	0	0	2	2	5	128
07/20/01	127.21	0	0	129	0	0	2	0	1	132
07/21/01	147.17	0	0	88	0	0	2	2	0	92
07/22/01	156.77	1	0	70	0	1	3	3	1	79
07/23/01	175.57	3	1	37	0	2	10	2	1	56
07/24/01	192.03	0	0	31	1	1	20	7	7	67
07/25/01	185.49	0	0	41	0	0	15	1	5	62
07/26/01	158.02	0	0	112	0	0	8	4	0	124
07/27/01	155.19	0	0	61	1	1	5	9	0	77
07/28/01	155.76	1	1	28	0	1	5	5	1	42
07/29/01	183.87	0	0	19	0	0	8	5	3	35
07/30/01	175.86	0	0	22	2	0	3	4	2	33
07/31/01	187.70	0	0	18	1	0	15	6	5	45
08/01/01	201.26	0	0	18	1	0	22	4	3	48
08/02/01	184.08	0	0	80	1	2	19	25	2	129
08/03/01	164.42	0	0	98	1	0	15	17	0	131
08/04/01	167.58	0	0	66	5	0	13	6	1	91
08/05/01	138.94	0	0	105	2	0	3	14	2	126
08/06/01	154.84	0	0	85	17	0	11	18	1	132
08/07/01	177.29	0	0	41	22	0	10	19	1	93
08/08/01	169.51	1	0	42	26	0	5	9	1	84
08/09/01	144.26	0	0	104	19	0	3	7	0	133
08/10/01	137.06	0	0	69	49	0	6	24	2	150
08/11/01	153.93	0	0	41	37	0	1	9	0	88
08/12/01	158.24	0	0	37	62	0	5	8	1	113
08/13/01	162.50	0	0	31	57	0	7	10	2	107
08/14/01	173.51	1	0	36	61	0	5	8	3	114
08/15/01	160.97	0	0	53	53	0	5	19	1	131
08/16/01	156.51	0	0	46	61	0	7	9	2	125
08/17/01	165.40	0	0	35	49	0	11	18	3	116
08/18/01	161.61	0	0	11	82	0	12	20	2	127
08/19/01	182.26	0	0	10	51	0	14	25	3	103
08/20/01	177.00	0	0	24	43	0	14	6	1	88
08/21/01	170.12	0	0	25	63	0	11	4	0	103
08/22/01	183.13	0	0	12	45	0	9	6	1	73
08/23/01	185.53	0	0	24	43	0	20	42	2	131
08/24/01	166.48	0	0	37	51	0	13	10	3	114
08/25/01	150.98	0	0	20	44	0	7	3	1	75
08/26/01	170.44	0	0	7	64	0	14	17	2	104
08/27/01	174.75	0	0	4	46	0	1	10	1	62
08/28/01	185.05	0	0	2	48	0	14	40	5	109
08/29/01	192.30	0	0	2	26	0	13	25	2	68
08/30/01	168.34	0	0	14	19	0	10	5	2	50
08/31/01	145.73	1	0	7	39	0	3	3	0	53
Fall Totals	7351.36	8	2	1961	1192	8	401	490	81	4143
Season Totals	13768.08	579	94	4188	1192	9	429	565	184	7240

Table 4. Daily estimates of fish passage by zone from 11 June to 18 July for the Yukon River sonar project, 2001.

Report Period	Date	Right Bank Passage	Right Bank SE	Left Bank Nearshore[a] Passage	Left Bank Nearshore[a] SE	Left Bank Offshore[b] Passage	Left Bank Offshore[b] SE	Total Passage	Total Passage SE	Total Passage CV	Percent Right Bank	Percent Left Bank
1	06/11/01	2,302	584	2,496	0	0	0	4,798	584	0.122	48.0	52.0
2	06/12/01	2,100	181	2,257	0	0	0	4,357	181	0.042	48.2	51.8
3	06/13/01	1,763	32	1,895	0	0	0	3,658	32	0.009	48.2	51.8
4	06/14/01	1,656	50	1,800	0	0	0	3,456	50	0.014	47.9	52.1
5	06/15/01	1,774	185	1,463	232	246	123	3,483	321	0.092	50.9	49.1
5	06/16/01	3,569	373	1,680	266	985	493	6,234	673	0.108	57.3	42.8
6	06/17/01	5,705	623	6,168	1048	713	57	12,586	1221	0.097	45.3	54.7
6	06/18/01	8,119	887	8,760	1489	1,409	112	18,288	1737	0.095	44.4	55.6
7	06/19/01	10,826	1082	11,688	0	1,580	648	24,094	1261	0.052	44.9	55.1
8	06/20/01	14,394	473	15,528	0	861	35	30,783	474	0.015	46.8	53.2
9	06/21/01	10,821	683	11,688	0	0	337	22,509	761	0.034	48.1	51.9
10	06/22/01	6,927	743	4,740	910	2,246	344	13,913	1224	0.088	49.8	50.2
11	06/23/01	6,326	32	4,845	744	1,147	224	12,318	778	0.063	51.4	48.6
12	06/24/01	8,227	1268	4,657	571	2,740	703	15,624	1558	0.1	52.7	47.3
13	06/25/01	7,374	560	10,266	2382	2,981	457	20,621	2489	0.121	35.8	64.2
14	06/26/01	11,161	1719	14,572	409	2,606	507	28,339	1838	0.065	39.4	60.6
15	06/27/01	16,770	570	23,307	3700	4,325	654	44,402	3800	0.086	37.8	62.2
16	06/28/01	13,271	2363	19,134	2129	5,471	1911	37,876	3711	0.098	35.0	65.0
17	06/29/01	13,489	150	18,420	1721	4,854	1485	36,763	2278	0.062	36.7	63.3
18	06/30/01	12,320	673	12,376	775	3,751	458	28,447	1124	0.04	43.3	56.7
18	07/01/01	9,897	541	11,282	706	3,625	443	24,804	994	0.04	39.9	60.1
19	07/02/01	6,882	568	5,746	149	3,110	415	15,738	719	0.046	43.7	56.3
20	07/03/01	4,022	264	6,805	408	2,723	138	13,550	505	0.037	29.7	70.3
20	07/04/01	4,127	271	6,531	392	2,489	126	13,147	492	0.037	31.4	68.6
21	07/05/01	3,690	200	8,872	1194	1,441	119	14,003	1217	0.087	26.4	73.7
22	07/06/01	3,630	449	10,009	40	1,523	256	15,162	519	0.034	23.9	76.1
23	07/07/01	4,238	112	13,968	874	2,328	658	20,534	1100	0.054	20.6	79.4
24	07/08/01	4,331	222	14,693	658	1,951	167	20,975	714	0.034	20.7	79.4
24	07/09/01	5,241	268	10,441	468	2,514	215	18,196	580	0.032	28.8	71.2
25	07/10/01	5,982	225	8,229	331	2,136	313	16,347	508	0.031	36.6	63.4
25	07/11/01	4,596	173	7,743	311	1,760	258	14,099	440	0.031	32.6	67.4
25	07/12/01	3,855	145	5,056	203	710	104	9,621	271	0.028	40.1	59.9
25	07/13/01	4,780	180	3,627	146	364	53	8,771	238	0.027	54.5	45.5
25	07/14/01	3,155	119	3,254	131	963	141	7,372	226	0.031	42.8	57.2
25	07/15/01	3,187	120	3,085	124	903	132	7,175	217	0.03	44.4	55.6
25	07/16/01	3,243	122	2,591	104	780	114	6,614	197	0.03	49.0	51.0
26	07/17/01	4,059	324	2,349	356	660	129	7,068	498	0.071	57.4	42.6
26	07/18/01	3,626	290	3,721	564	1,411	276	8,758	691	0.079	41.4	58.6
SUMMER TOTALS		241,435	4,111	305,742	6,100	67,306	3,121	614,483	7,991			

[a]Left Bank Nearshore Range:0-50 m

[b]Left Bank Offshore Range: 50-245 m

Table 5. Daily estimates of fish passage by zone from 19 July to 31 August for the Yukon River sonar project, 2001.

Report Period	Date	Right Bank Passage	Right Bank SE	Left Bank Nearshore[a] Passage	Left Bank Nearshore[a] SE	Left Bank Offshore[b] Passage	Left Bank Offshore[b] SE	Total Passage	Total Passage SE	Total Passage CV	Percent Right Bank	Percent Left Bank
27	07/19/01	6,132	484	12,960	902	3,114	298	22,206	1066	0.048	27.6	72.4
27	07/20/01	10,495	828	26,158	1820	6,524	625	43,177	2095	0.049	24.3	75.7
28	07/21/01	8,763	597	18,561	1581	6,186	187	33,510	1700	0.051	26.2	73.9
29	07/22/01	4,533	420	8,086	750	4,023	396	16,642	946	0.057	27.2	72.8
29	07/23/01	5,697	528	3,409	316	2,037	201	11,143	647	0.058	51.1	48.9
30	07/24/01	5,177	712	3,594	369	1,982	235	10,753	836	0.078	48.1	51.9
30	07/25/01	7,505	1033	5,334	547	2,530	300	15,369	1207	0.079	48.8	51.2
31	07/26/01	7,654	738	9,520	671	3,946	528	21,120	1129	0.053	36.2	63.8
32	07/27/01	6,738	411	8,564	355	4,603	749	19,905	926	0.047	33.9	66.2
33	07/28/01	3,722	273	4,617	323	3,477	282	11,816	508	0.043	31.5	68.5
33	07/29/01	2,031	149	3,203	224	2,113	171	7,347	319	0.043	27.6	72.4
33	07/30/01	3,054	224	3,312	231	2,259	183	8,625	370	0.043	35.4	64.6
33	07/31/01	2,830	207	3,346	234	2,579	209	8,755	376	0.043	32.3	67.7
33	08/01/01	3,080	226	2,183	153	1,442	117	6,705	296	0.044	45.9	54.1
34	08/02/01	6,255	1722	7,760	1669	4,133	983	18,148	2592	0.143	34.5	65.5
35	08/03/01	6,042	442	9,213	476	7,828	1375	23,083	1521	0.066	26.2	73.8
35	08/04/01	6,158	450	10,035	519	5,165	907	21,358	1138	0.053	28.8	71.2
36	08/05/01	8,273	481	15,886	1242	7,371	388	31,530	1387	0.044	26.2	73.8
37	08/06/01	7,987	385	11,913	951	6,271	469	26,171	1129	0.043	30.5	69.5
37	08/07/01	6,614	319	6,735	538	4,235	317	17,584	701	0.04	37.6	62.4
38	08/08/01	7,569	933	5,998	447	2,849	271	16,416	1070	0.065	46.1	53.9
39	08/09/01	18,277	1010	11,800	907	0	654	30,077	1507	0.05	60.8	39.2
40	08/10/01	15,667	1017	12,552	752	6,874	482	35,093	1353	0.039	44.6	55.4
40	08/11/01	9,200	597	8,837	529	6,263	439	24,300	910	0.037	37.9	62.1
41	08/12/01	8,572	203	5,914	257	5,276	508	19,762	605	0.031	43.4	56.6
42	08/13/01	7,493	207	5,673	594	6,602	674	19,768	922	0.047	37.9	62.1
43	08/14/01	7,281	191	6,020	864	6,483	514	19,784	1024	0.052	36.8	63.2
44	08/15/01	9,804	810	8,342	541	6,960	611	25,106	1150	0.046	39.1	61.0
45	08/16/01	9,293	710	8,552	129	7,184	185	25,029	745	0.03	37.1	62.9
46	08/17/01	8,564	300	5,785	591	5,917	435	20,266	793	0.039	42.3	57.7
47	08/18/01	6,493	377	4,987	1136	6,915	1281	18,395	1754	0.095	35.3	64.7
48	08/19/01	6,968	927	3,130	330	2,706	424	12,804	1071	0.084	54.4	45.6
48	08/20/01	9,163	1219	4,368	461	2,220	348	15,751	1349	0.086	58.2	41.8
49	08/21/01	6,343	360	5,313	545	4,280	295	15,936	717	0.045	39.8	60.2
49	08/22/01	4,211	239	4,242	435	3,855	265	12,308	563	0.046	34.2	65.8
50	08/23/01	5,623	571	6,054	487	3,048	236	14,725	787	0.053	38.2	61.8
51	08/24/01	6,829	413	6,359	567	3,360	246	16,548	743	0.045	41.3	58.7
51	08/25/01	5,250	318	5,639	503	3,671	269	14,560	652	0.045	36.1	63.9
52	08/26/01	6,407	473	4,912	361	3,423	202	14,742	628	0.043	43.5	56.5
53	08/27/01	5,395	976	2,536	130	2,034	367	9,965	1051	0.105	54.1	45.9
54	08/28/01	4,952	464	3,352	649	1,600	184	9,904	818	0.083	50.0	50.0
54	08/29/01	3,938	369	1,846	357	997	115	6,781	526	0.078	58.1	41.9
55	08/30/01	3,724	382	2,320	88	1,576	104	7,620	406	0.053	48.9	51.1
55	08/31/01	4,322	443	2,111	80	1,321	87	7,754	459	0.059	55.7	44.3
FALL TOTALS		300,078	4,231	311,031	4,681	177,232	3,328	788,341	7,134			
SEASON TOTALS		541,513	5,899	616,773	7,690	244,538	4,563	1,402,824	10,712			

[a]Left Bank Nearshore Range:0-50 m
[b]Left Bank Offshore Range: 50-245 m

Table 6. Cumulative passage estimates by species for the Yukon River sonar project, 2001.

Species	Cumulative Estimated Passage	Standard Error	Coefficient of Variation	Lower 90% Confidence Interval
Target Species				
Large Chinook Salmon	118,935	6,646	0.056	108,003
Small Chinook Salmon	18,518	2,426	0.131	14,528
	==========			
Total Chinook Salmon	137,453			
Summer Chum	394,078	10,204	0.026	377,292
Fall Chum	360,356	13,300	0.037	338,477
	==========			
Total Chum	754,434			
Non-target Species[a]				
Coho Salmon	143,213	9,048	0.063	128,330
Pink Salmon	1,279	416	0.325	594
Non-salmon	371,327	14,537	0.039	[illegible]
	==========			
Total	1,407,706			

[a]Estimates used in the process of apportioning target species, not for estimating passage rates of n

Table 7. Daily estimates of fish passage by species from 11 June to 18 July for the Yukon River sonar project, 2001.

Report Peroid	Date	Large Chinook	Small Chinook	Summer Chum	Pink	Non Salmon	Total All Species
1	11-Jun-01	541	0	0	0	4,257	4,798
2	12-Jun-01	1,113	155	0	0	3,088	4,356
3	13-Jun-01	2,569	135	239	0	716	3,659
4	14-Jun-01	2,126	126	229	0	975	3,456
5	15-Jun-01	1,104	254	648	0	1,478	3,484
5	16-Jun-01	2,088	307	939	0	2,899	6,233
6	17-Jun-01	3,093	79	8,635	0	779	12,586
6	18-Jun-01	4,455	112	12,612	0	1,109	18,288
7	19-Jun-01	5,506	421	15,729	0	2,437	24,093
8	20-Jun-01	7,120	1,976	20,204	0	1,480	30,780
9	21-Jun-01	3,552	322	16,139	0	2,494	22,507
10	22-Jun-01	1,765	788	9,841	0	1,520	13,914
11	23-Jun-01	3,623	388	8,307	0	0	12,318
12	24-Jun-01	2,541	187	11,729	0	1,168	15,625
13	25-Jun-01	2,495	872	16,344	0	909	20,620
14	26-Jun-01	7,209	1,203	18,922	0	1,004	28,338
15	27-Jun-01	10,081	1,799	31,140	0	1,380	44,400
16	28-Jun-01	8,420	1,134	25,554	0	2,767	37,875
17	29-Jun-01	8,131	972	26,937	0	725	36,765
18	30-Jun-01	4,806	723	17,083	0	5,836	28,448
18	1-Jul-01	4,327	648	15,140	0	4,688	24,803
19	2-Jul-01	2,784	542	10,421	0	1,988	15,735
20	3-Jul-01	2,467	1,135	9,511	0	438	13,551
20	4-Jul-01	2,383	1,050	9,264	0	449	13,146
21	5-Jul-01	3,121	204	10,553	0	124	14,002
22	6-Jul-01	2,813	959	9,297	0	2,092	15,161
23	7-Jul-01	2,819	115	15,601	0	1,999	20,534
24	8-Jul-01	3,983	205	16,370	0	419	20,977
24	9-Jul-01	2,976	248	14,466	0	507	18,197
25	10-Jul-01	1,558	249	8,952	0	5,588	16,347
25	11-Jul-01	1,412	191	7,795	0	4,700	14,098
25	12-Jul-01	967	160	4,964	0	3,530	9,621
25	13-Jul-01	799	199	4,154	0	3,620	8,772
25	14-Jul-01	657	131	3,947	0	2,636	7,371
25	15-Jul-01	634	133	3,805	0	2,605	7,177
25	16-Jul-01	562	135	3,423	0	2,493	6,613
26	17-Jul-01	249	0	2,173	50	4,596	7,068
26	18-Jul-01	353	0	3,011	44	5,349	8,757
Summer Totals		117,202	18,257	394,078	94	84,842	614,473

Table 8. Daily estimates of fish passage by species from 19 July to 31 August for the Yukon River sonar project, 2001.

Report Peroid	Date	Large Chinook	Small Chinook	Pink	Fall Chum	Coho	Non Salmon	Total All Species
27	19-Jul-01	0	0	0	18,964	0	3,242	22,206
27	20-Jul-01	0	0	0	36,988	0	6,189	43,177
28	21-Jul-01	0	0	0	29,306	0	4,204	33,510
29	22-Jul-01	452	25	389	10,843	0	4,933	16,642
29	23-Jul-01	317	31	187	5,310	0	5,297	11,142
30	24-Jul-01	0	0	68	4,999	75	5,611	10,753
30	25-Jul-01	0	0	98	6,960	111	8,200	15,369
31	26-Jul-01	0	0	0	15,511	0	5,609	21,120
32	27-Jul-01	0	0	257	13,488	343	5,817	19,905
33	28-Jul-01	121	57	27	6,007	136	5,468	11,816
33	29-Jul-01	84	39	15	3,804	90	3,315	7,347
33	30-Jul-01	87	41	22	4,119	101	4,256	8,626
33	31-Jul-01	88	41	21	4,428	99	4,077	8,754
33	1-Aug-01	57	27	23	2,793	74	3,729	6,703
34	2-Aug-01	0	0	78	9,831	58	8,183	18,150
35	3-Aug-01	0	0	0	14,498	620	7,965	23,083
35	4-Aug-01	0	0	0	12,319	668	8,371	21,358
36	5-Aug-01	0	0	0	20,259	345	10,927	31,531
37	6-Aug-01	0	0	0	11,177	3,798	11,194	26,169
37	7-Aug-01	0	0	0	7,155	2,353	8,075	17,583
38	8-Aug-01	264	0	0	8,080	3,147	4,926	16,417
39	9-Aug-01	0	0	0	21,808	6,225	6,941	34,974
40	10-Aug-01	0	0	0	8,975	7,323	18,794	35,092
40	11-Aug-01	0	0	0	6,781	5,898	11,620	24,299
41	12-Aug-01	0	0	0	8,536	6,095	5,131	19,762
42	13-Aug-01	0	0	0	8,730	6,438	4,600	19,768
43	14-Aug-01	135	0	0	5,008	10,166	4,476	19,785
44	15-Aug-01	0	0	0	9,012	9,078	7,016	25,106
45	16-Aug-01	0	0	0	7,422	9,977	7,630	25,029
46	17-Aug-01	0	0	0	3,952	7,193	9,120	20,265
47	18-Aug-01	0	0	0	3,124	7,031	8,240	18,395
48	19-Aug-01	0	0	0	2,573	3,676	6,553	12,802
48	20-Aug-01	0	0	0	2,936	4,127	8,688	15,751
49	21-Aug-01	0	0	0	3,888	6,512	5,536	15,936
49	22-Aug-01	0	0	0	3,079	5,296	3,933	12,308
50	23-Aug-01	0	0	0	2,676	4,361	7,688	14,725
51	24-Aug-01	0	0	0	4,866	5,619	6,064	16,549
51	25-Aug-01	0	0	0	4,420	5,258	4,883	14,561
52	26-Aug-01	0	0	0	1,406	6,601	6,735	14,742
53	27-Aug-01	0	0	0	460	4,949	4,555	9,964
54	28-Aug-01	0	0	0	109	2,265	7,529	9,903
54	29-Aug-01	0	0	0	66	1,397	5,319	6,782
55	30-Aug-01	59	0	0	1,903	2,842	2,816	7,620
55	31-Aug-01	69	0	0	1,787	2,868	3,030	7,754
Fall Totals		1,733	261	1,185	360,356	143,213	286,485	793,233
Season Totals		118,935	18,518	1,279	360,356	143,213	371,327	1,407,706

Table 9. Comparison of 24-hour sampling estimates with daily nine-hour sampling estimates for the Yukon River sonar project, 2001.

Date	Sampling Method	Right Bank Passage	Left Bank Nearshore Passage	Left Bank Offshore Passage	Total Passage	Total % Differences
7/3/01	24-hr	4,130	5,952	3,153	13,235	-2.33%
	9-hr	4,022	6,806	2,723	13,551	
7/20/01	24-hr	10,956	22,632	6,226	39,814	-7.79%
	9-hr	10,495	26,158	6,524	43,177	
8/6/01	24-hr	8,296	12,784	6,599	27,679	5.77%
	9-hr	7,985	11,913	6,271	26,169	
8/19/01	24-hr	7,425	3,063	2,855	13,343	4.23%
	9-hr	6,967	3,129	2,706	12,802	
		========	========	========	========	
TOTAL	24-hr	30,807	44,431	18,833	94,071	-1.70%
	9-hr	29,469	48,006	18,224	95,699	
% Differences by zone:		4.54%	-7.45%	3.34%	-1.70%	

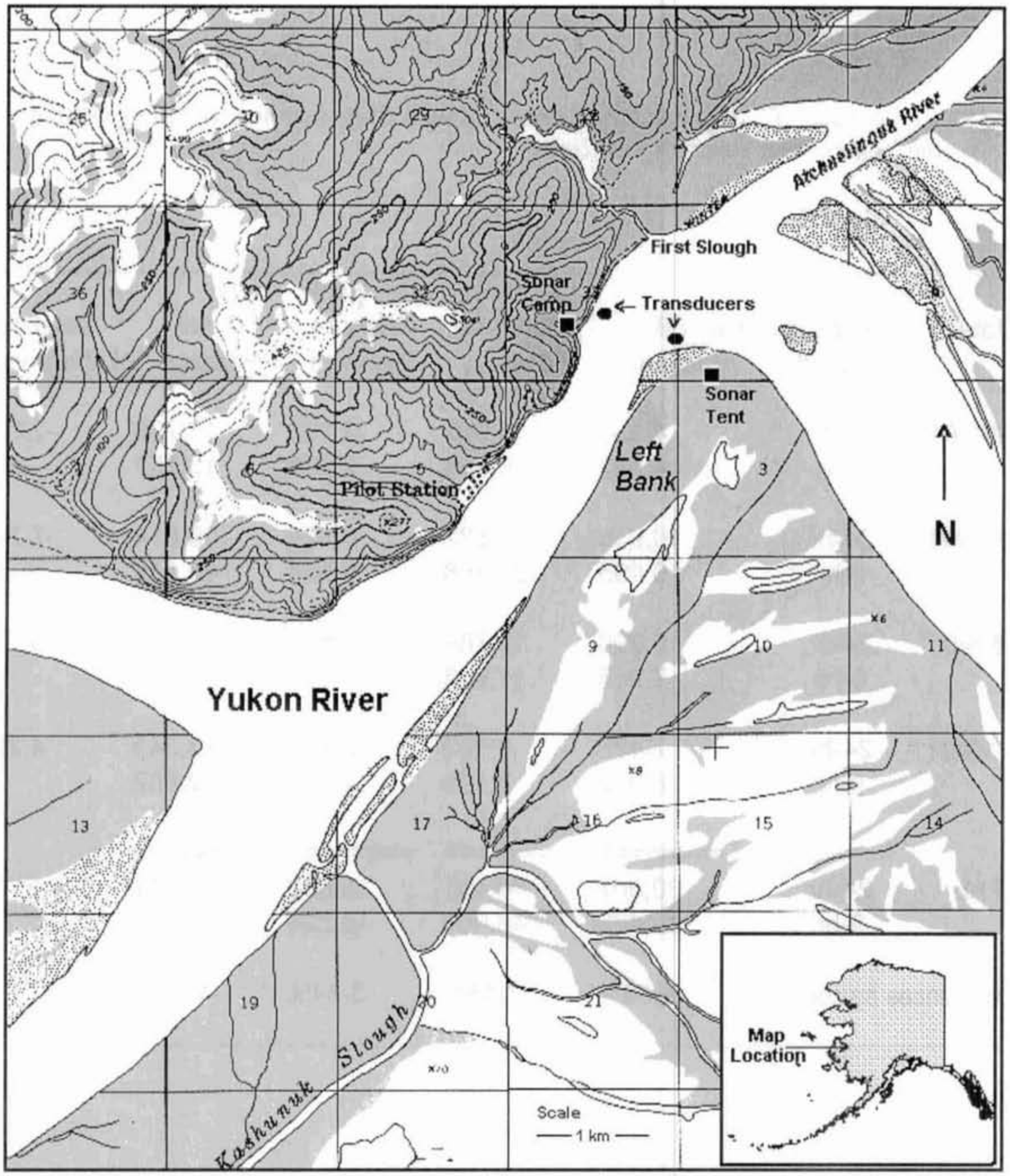


Figure 1. Topographical map of the Yukon River in the vicinity of the sonar site.

Right Bank Pod 7/6/01

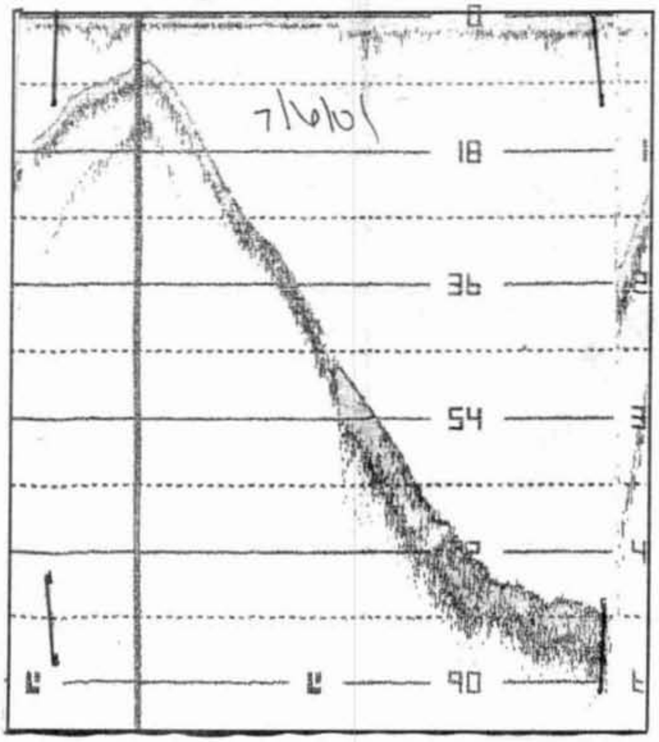
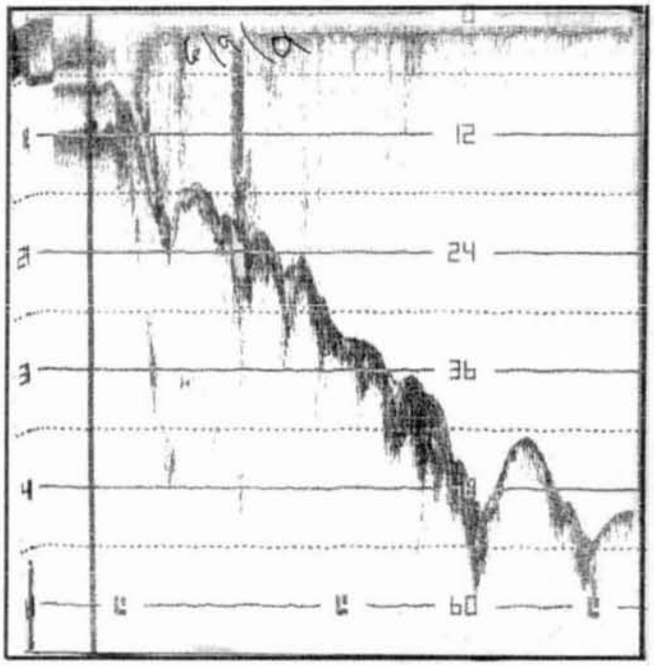


Figure 2. Yukon River right-bank profile recorded on 6 July, 2001.

Left Bank Sonar Tent 6/9/01



Left Bank Pod 7/6/01

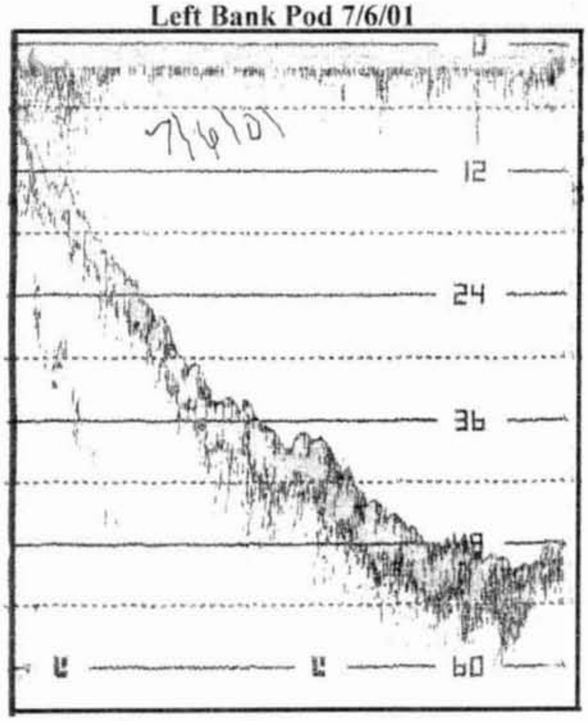


Figure 3. Yukon River left-bank profile recorded on 9 June 2001, (top) and 7 July, 2001 (bottom).

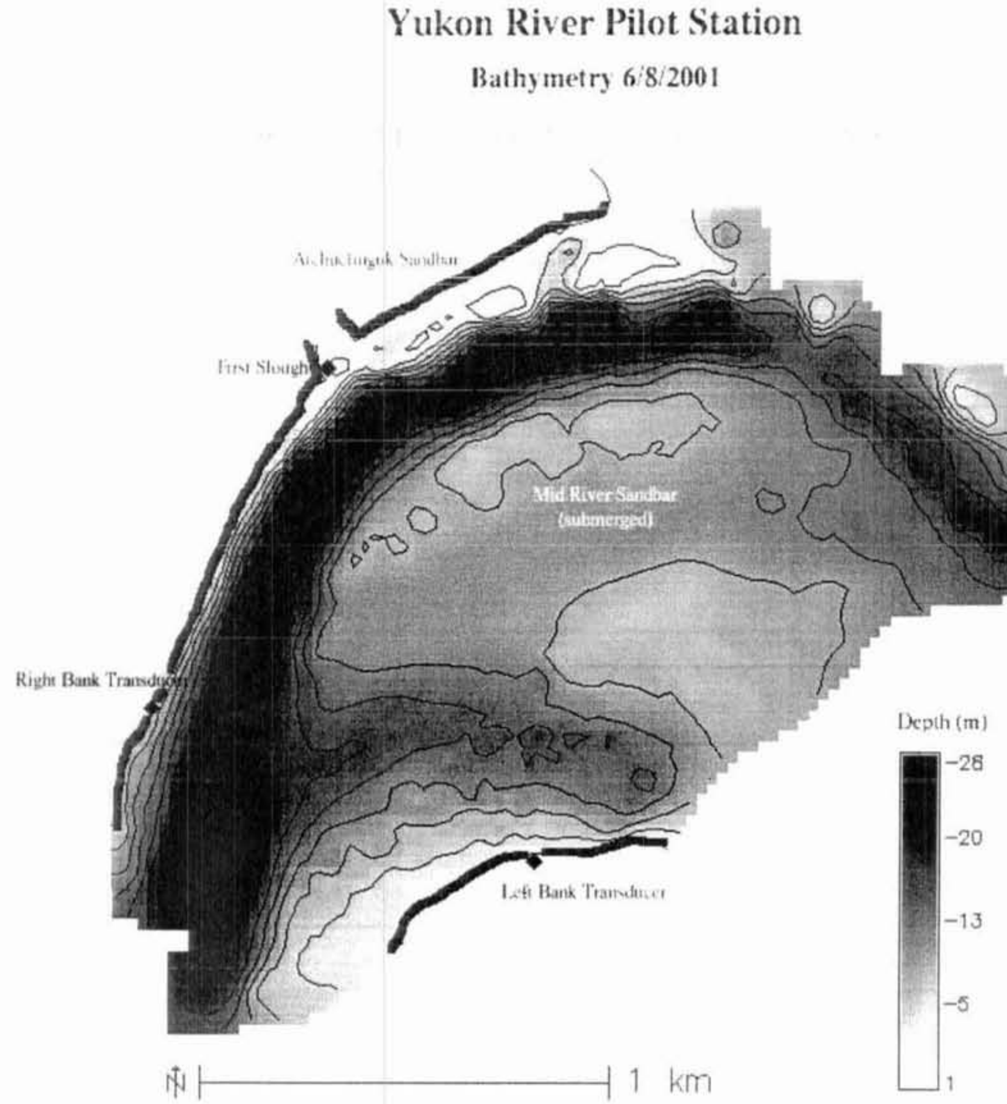


Figure 4. Bathymetric map of the Yukon River sonar sampling area, 2001.

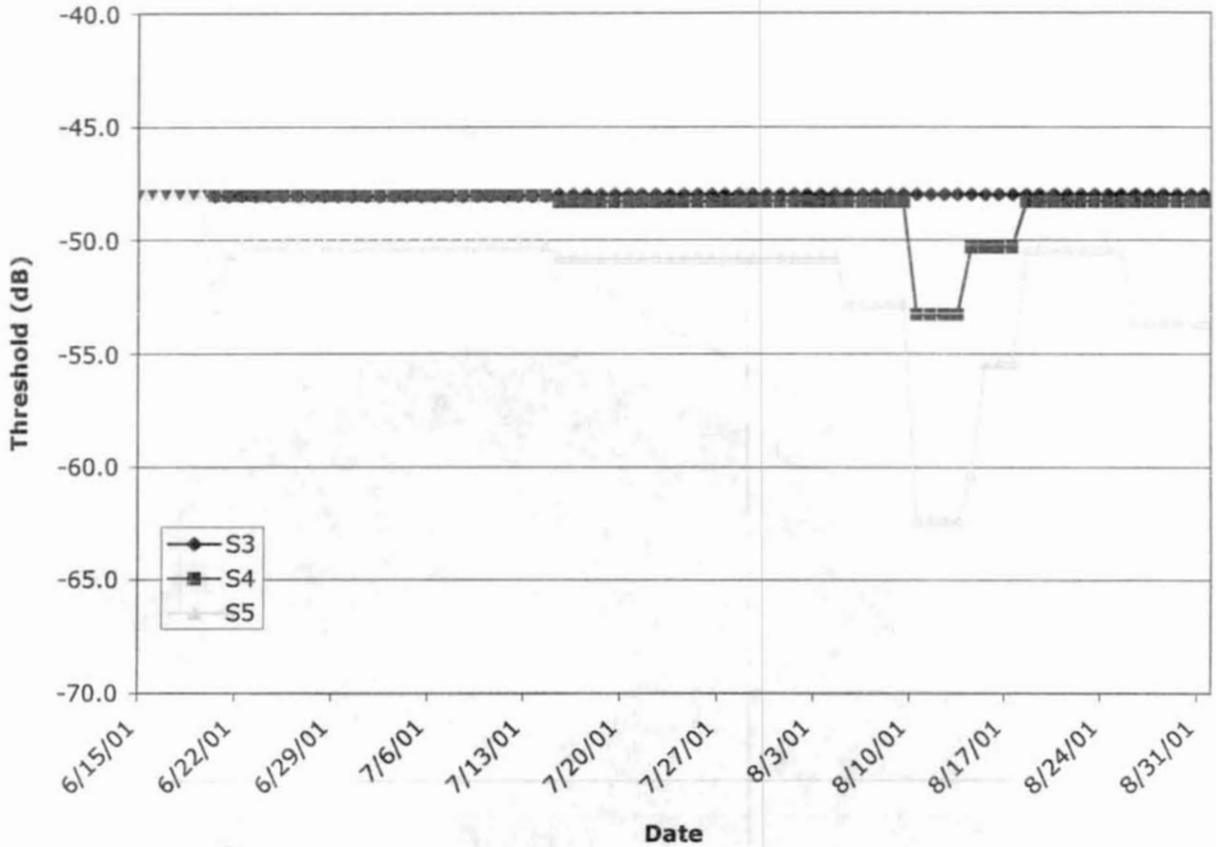
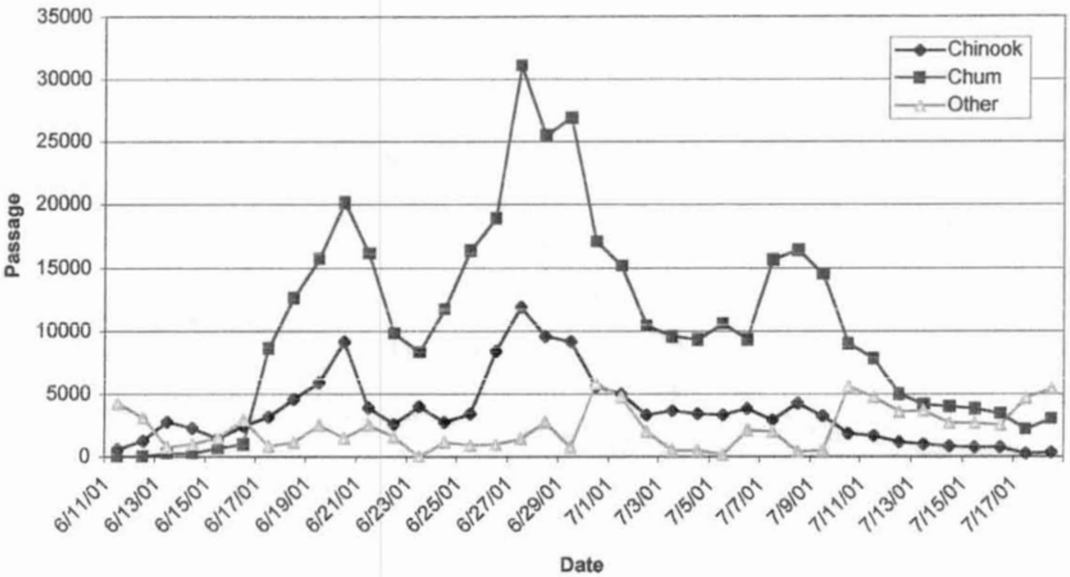


Figure 5. Thresholds used on the left bank by strata and day, Yukon River sonar project, 2001.



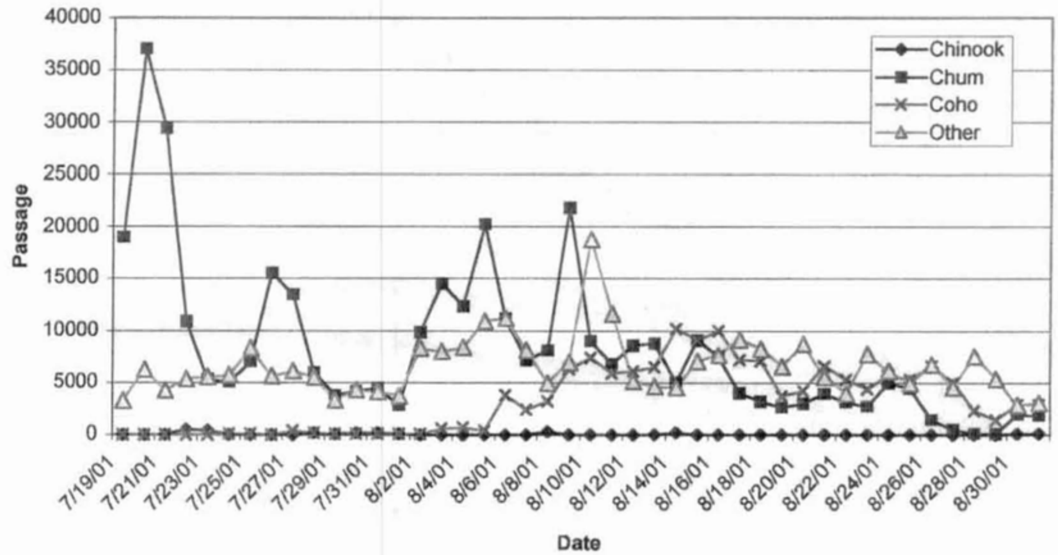
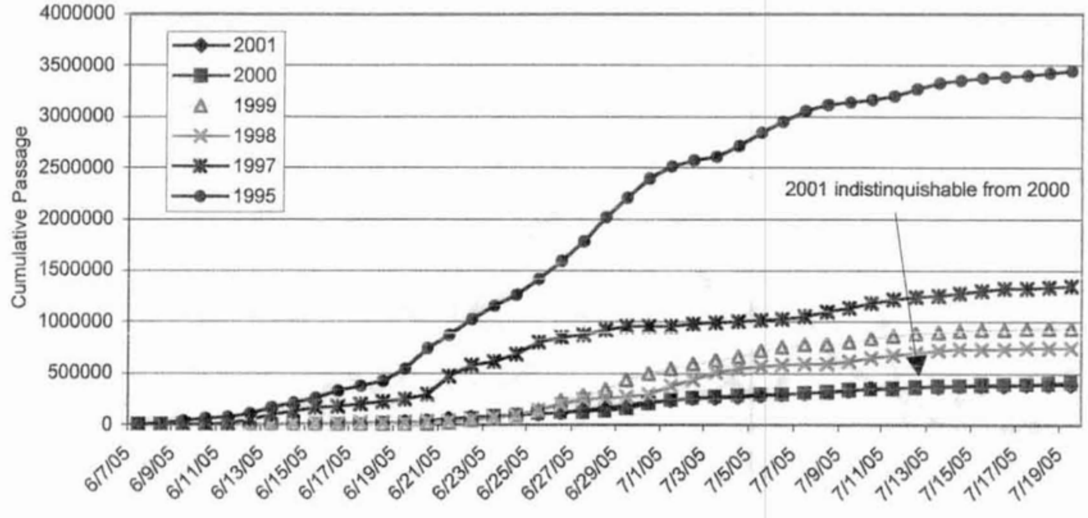


Figure 6. Estimated daily passage by species for summer (top) and fall (bottom) seasons, Yukon River sonar project, 2001.



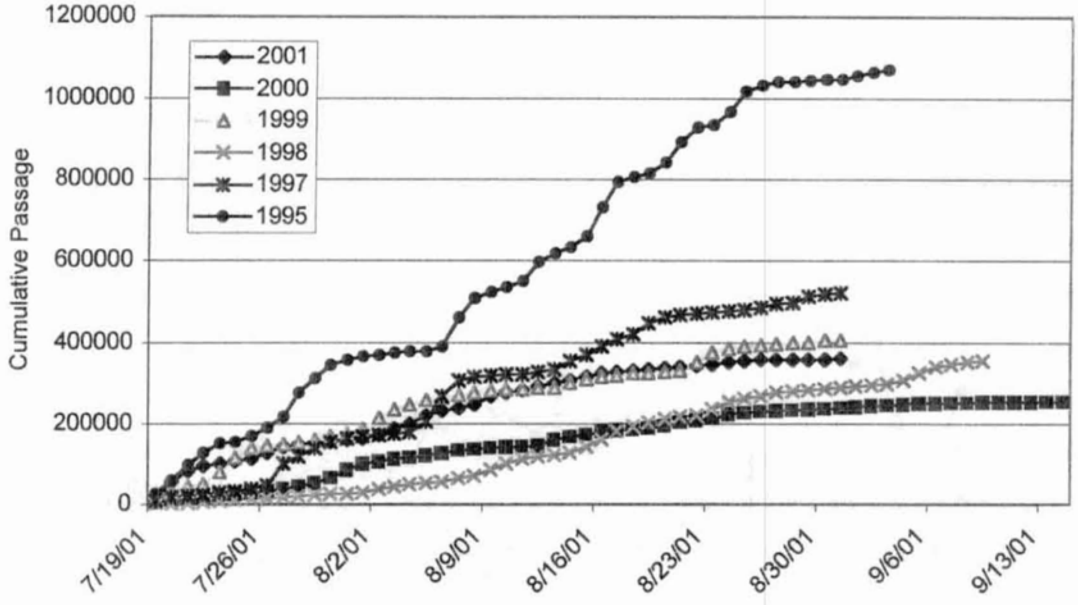
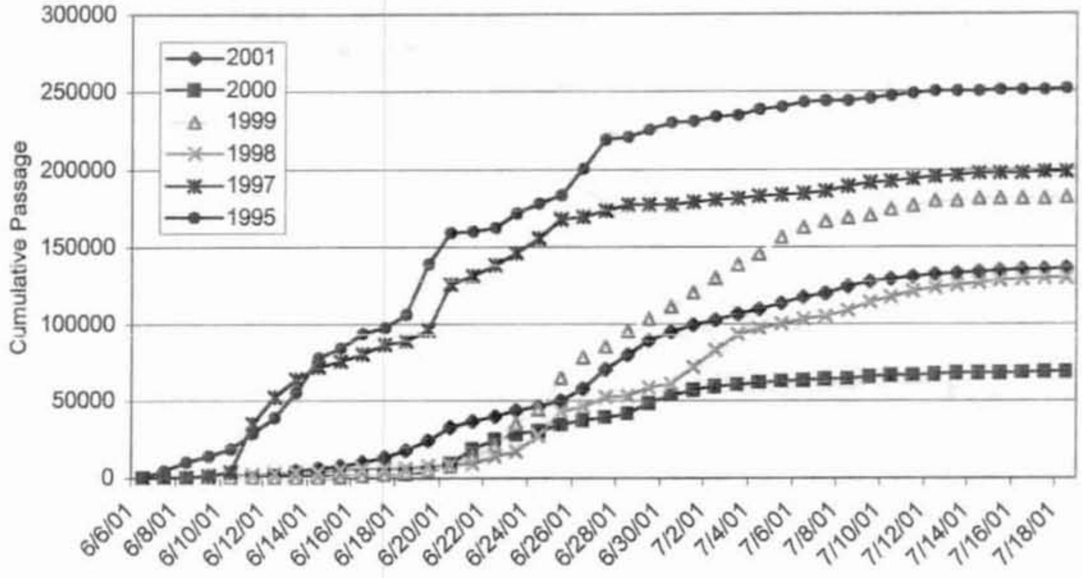


Figure 7. Cumulative passage for summer chum salmon (top) and fall chum salmon (bottom), Yukon River sonar project, 1995 through 2001.



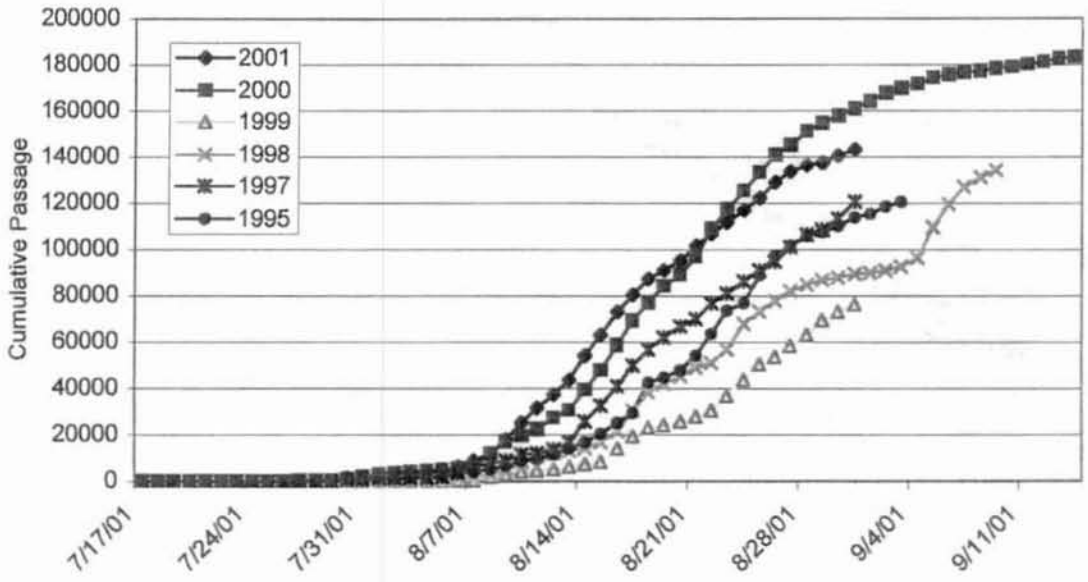
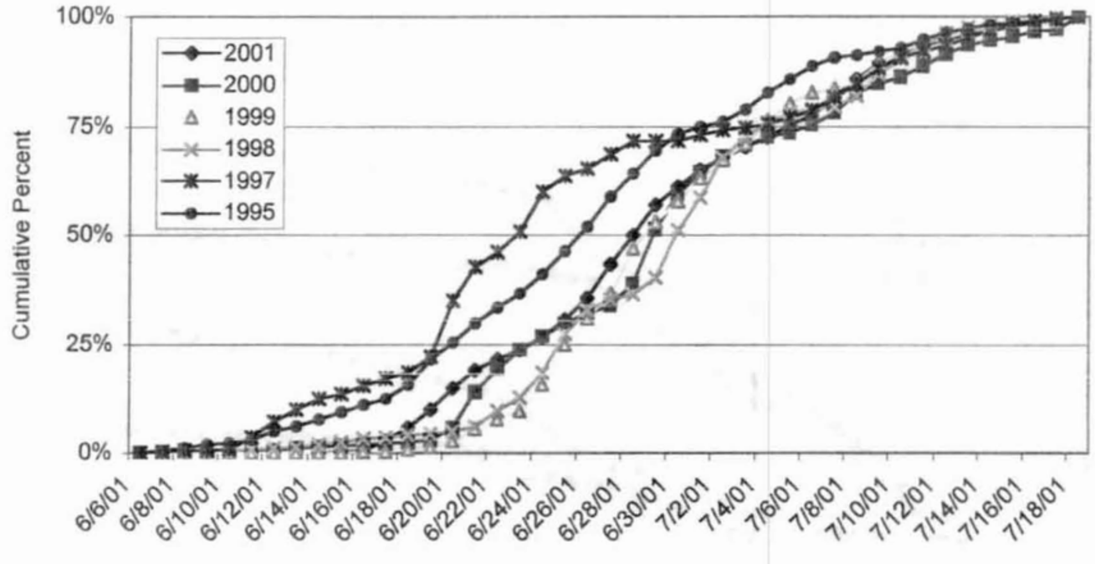


Figure 8. Cumulative passage for chinook (top) and coho salmon (bottom), Yukon River sonar project, 1995 through 2001.



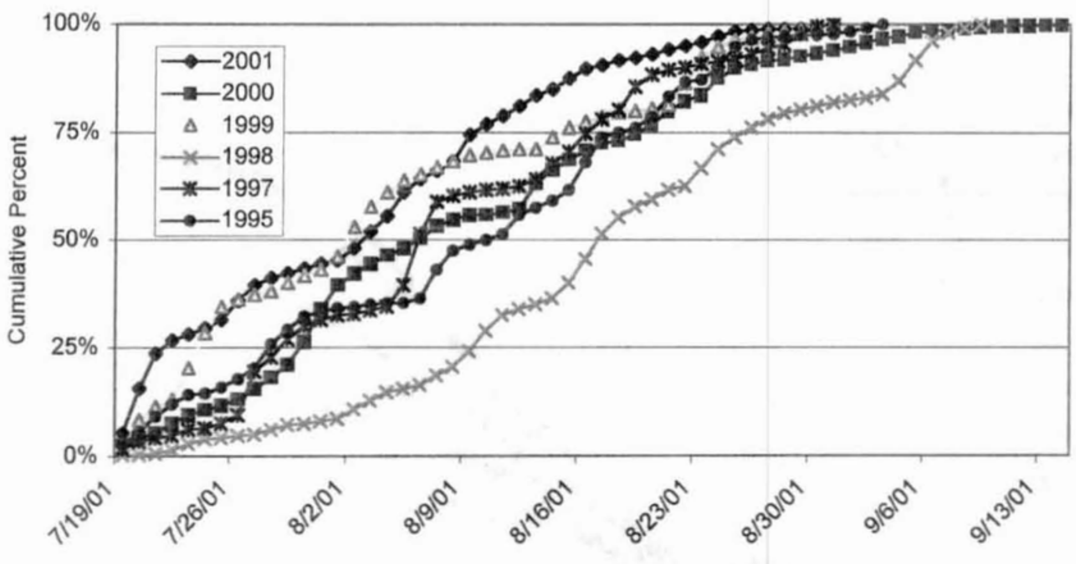


Figure 9. Cumulative percent of total passage by day for summer (top) and fall (bottom) chum salmon, Yukon River sonar project, 1995 through 2001.

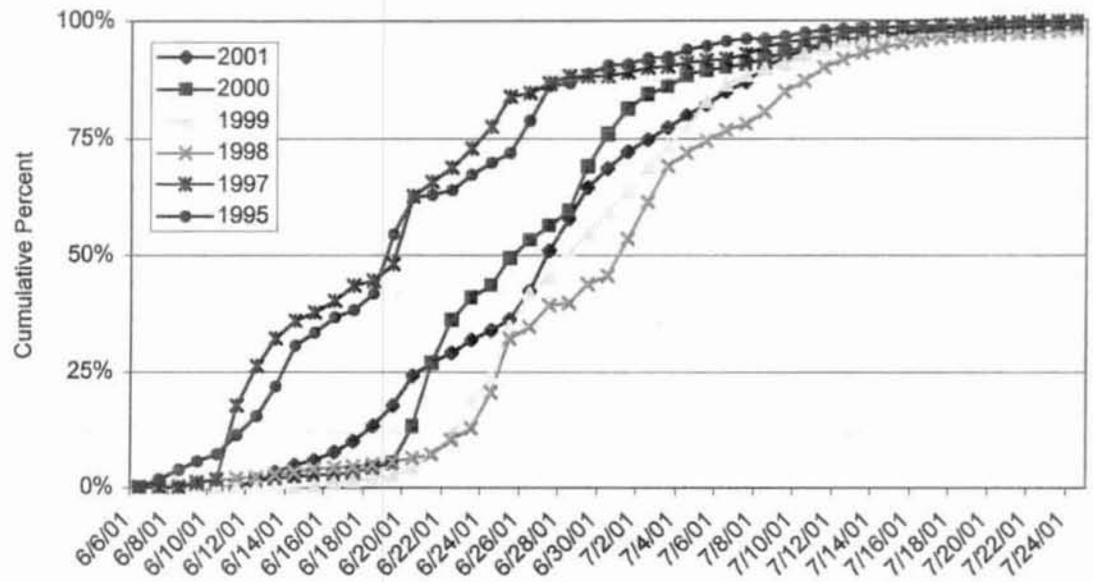


Figure 10. Cumulative percent of total passage by day for chinook salmon, Yukon River sonar project, 1995 through 2001.

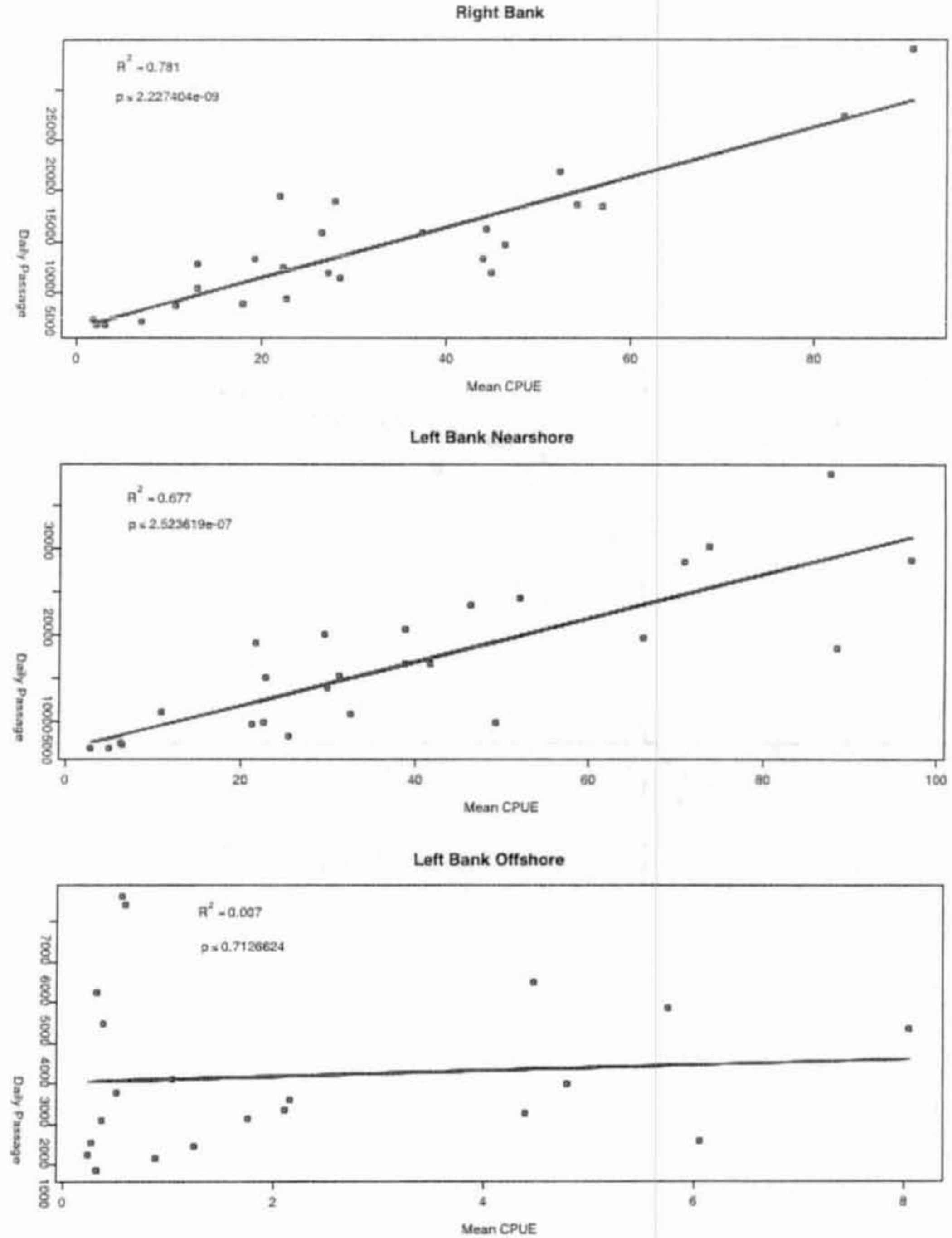


Figure 11. Mean CPUE versus daily sonar passage estimates by zone from 11 June to 18 July for the Yukon River sonar project, 2001.

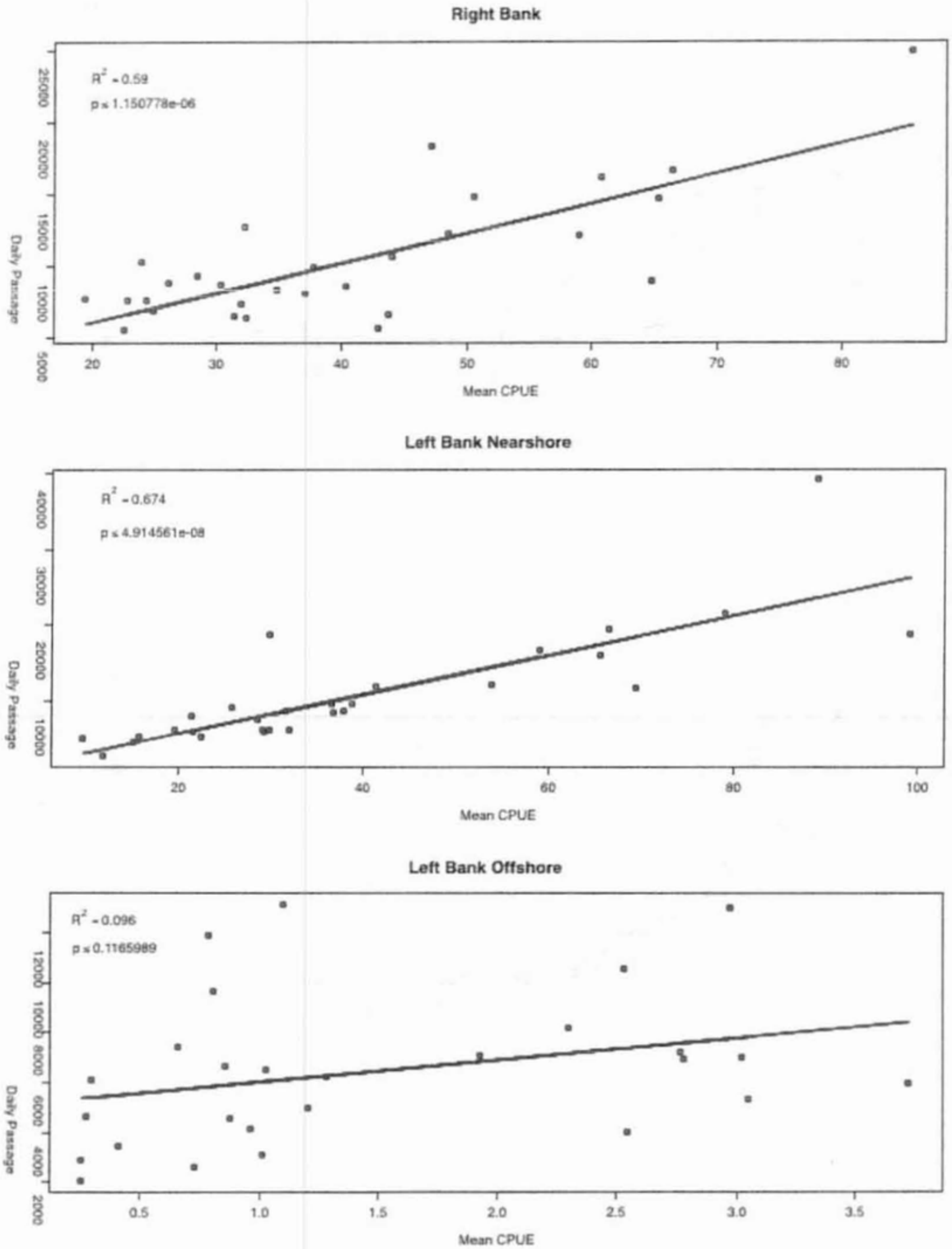
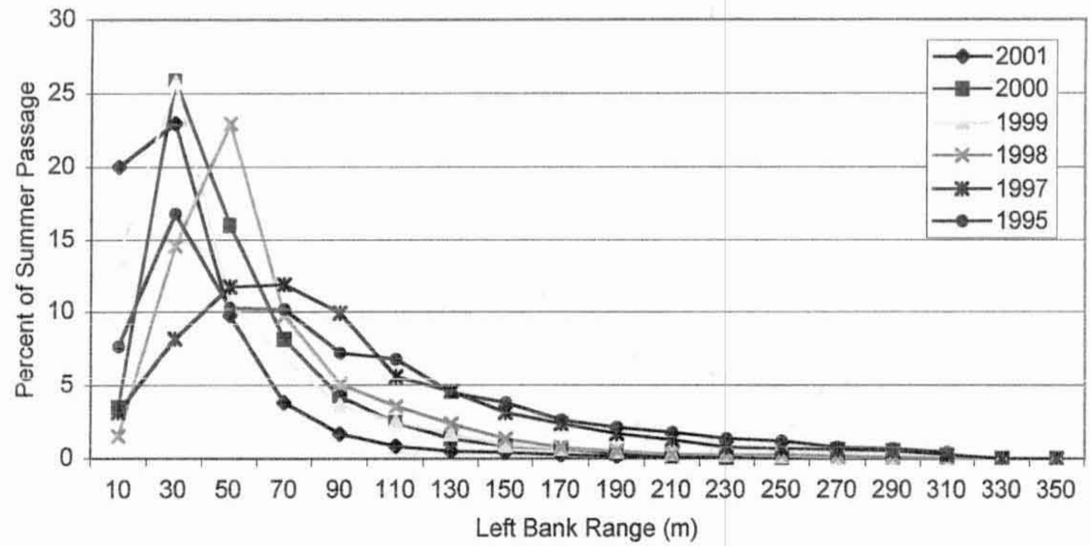


Figure 12. Mean CPUE versus daily sonar passage estimates by zone from 19 July to 31 August for the Yukon River sonar project, 2001.



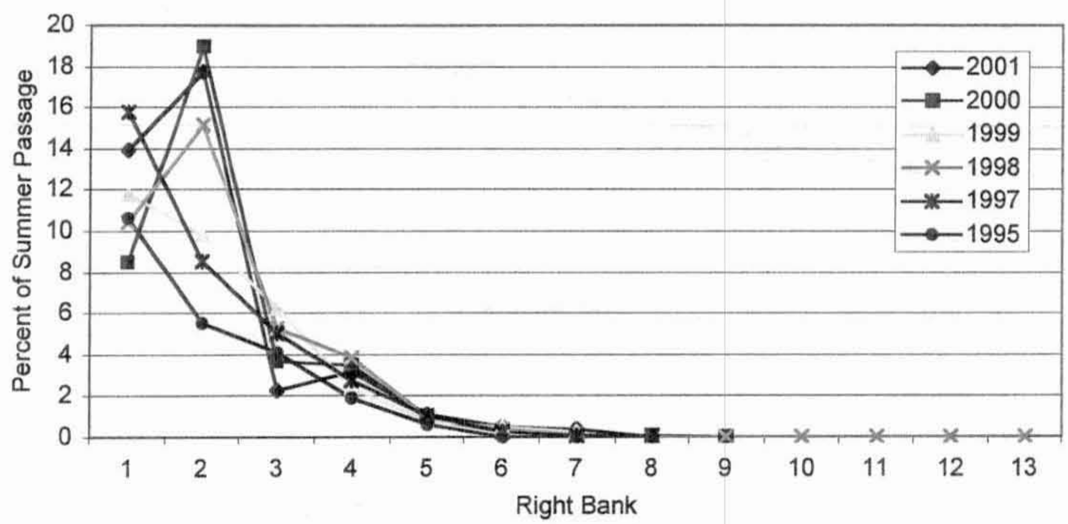
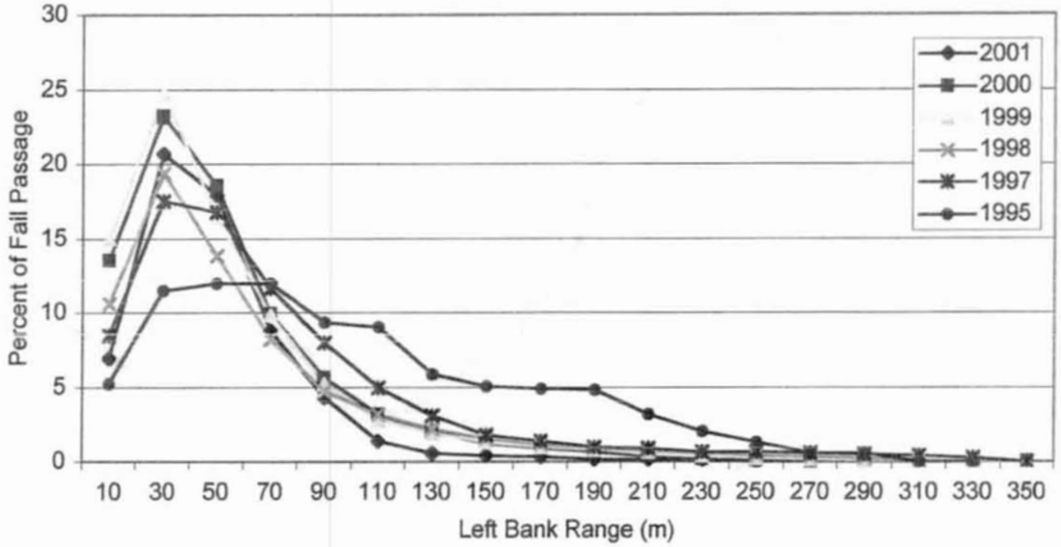


Figure 13. Horizontal distribution of left (top) and right (bottom) bank passage estimates for the Yukon River sonar project from 12 June through 18 July, 1995 through 2001.



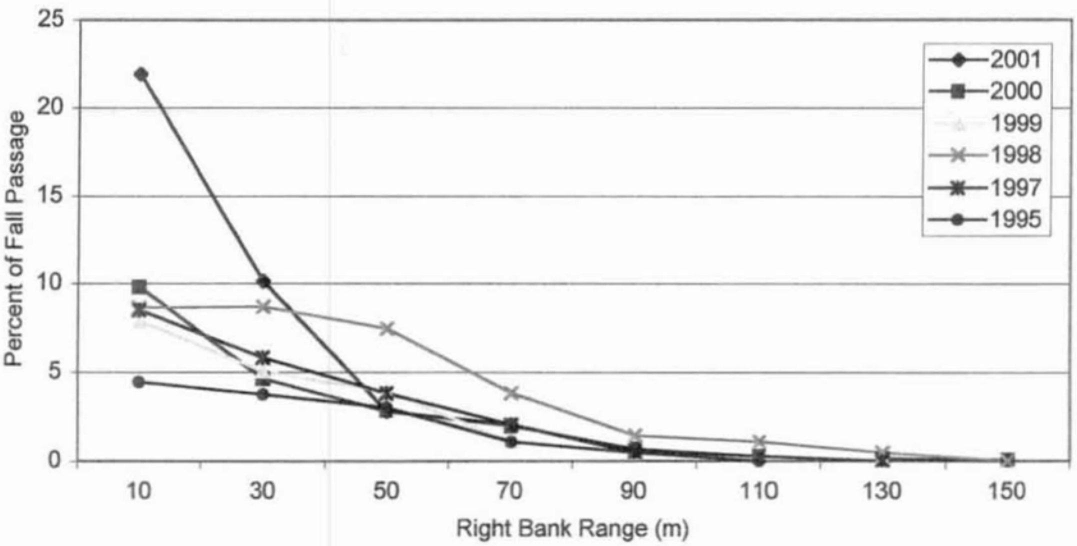


Figure 14. Horizontal distribution of left (top) and right (bottom) bank passage estimates for the Yukon River sonar project from 19 July through 31 August, 1995 through 2001.

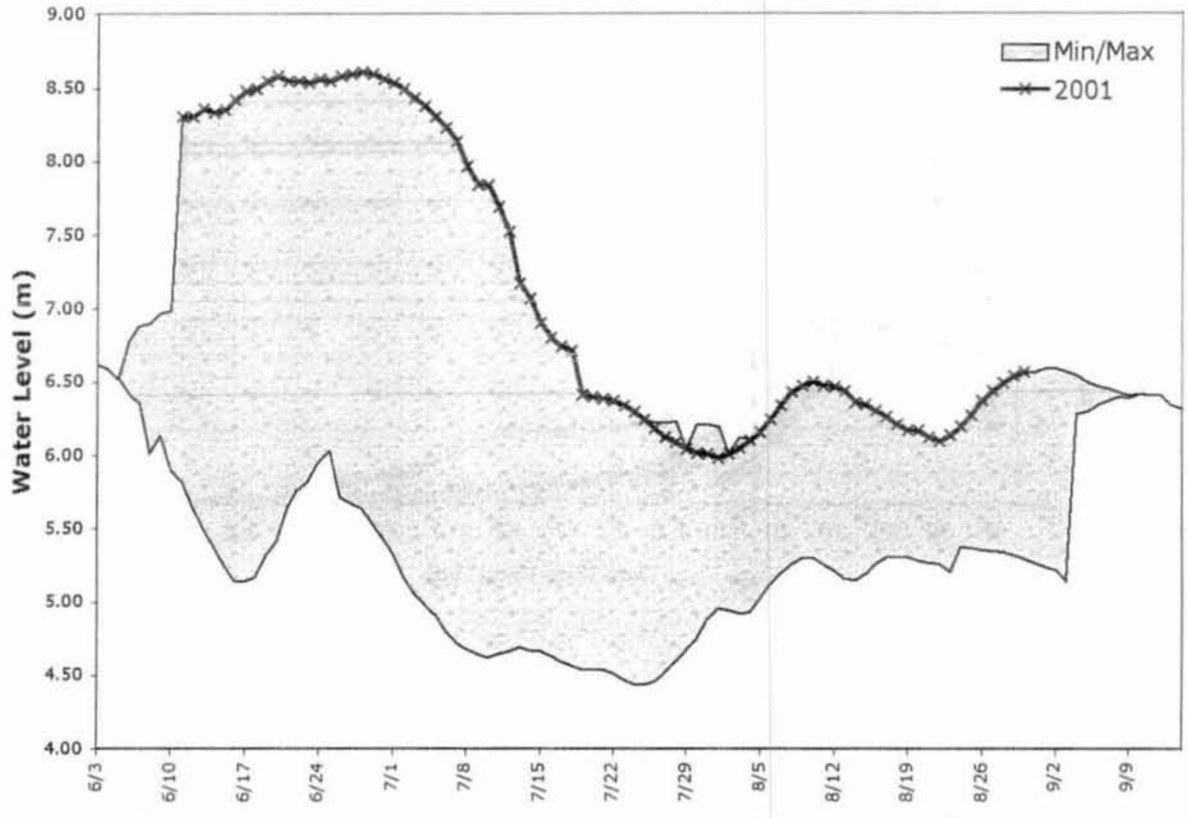


Figure 15. Comparison of the 2001 daily water level to the maximum and minimum values recorded at the Yukon River sonar project from the years 1995 through 2001.

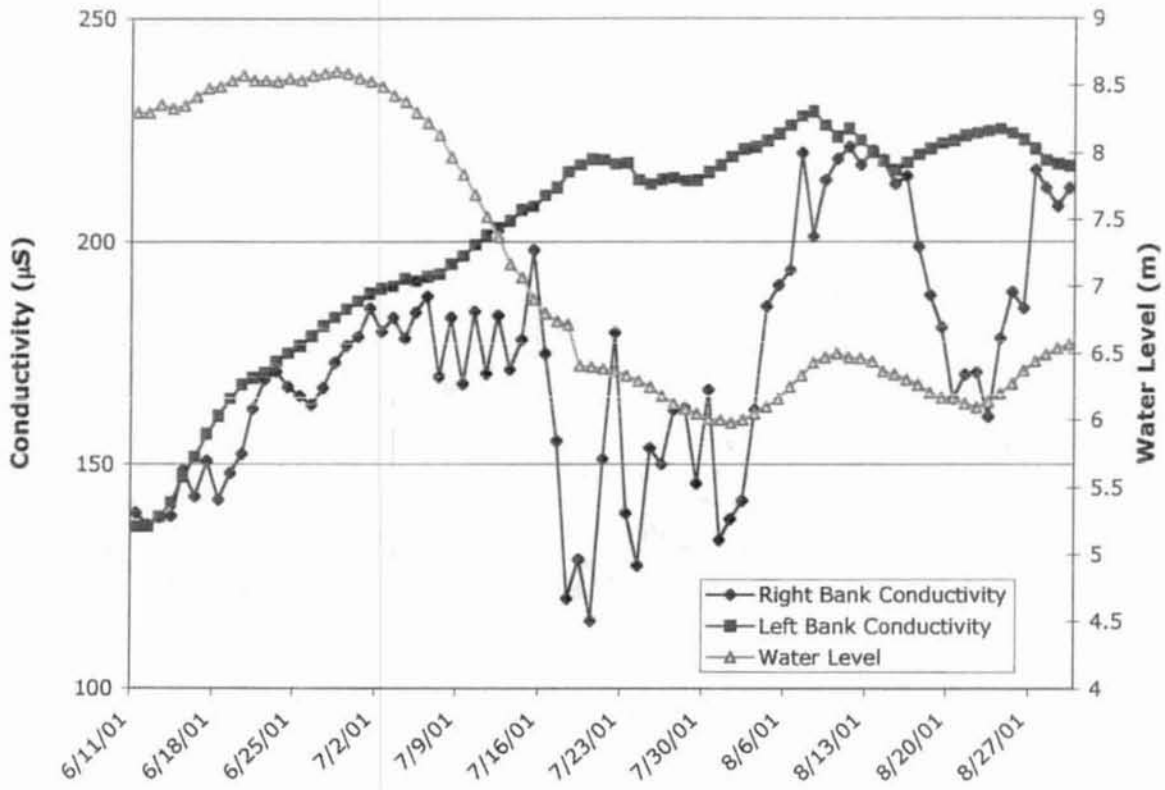


Figure 16. Daily Yukon River conductivity and water level recorded at the Yukon River sonar site, 2001.

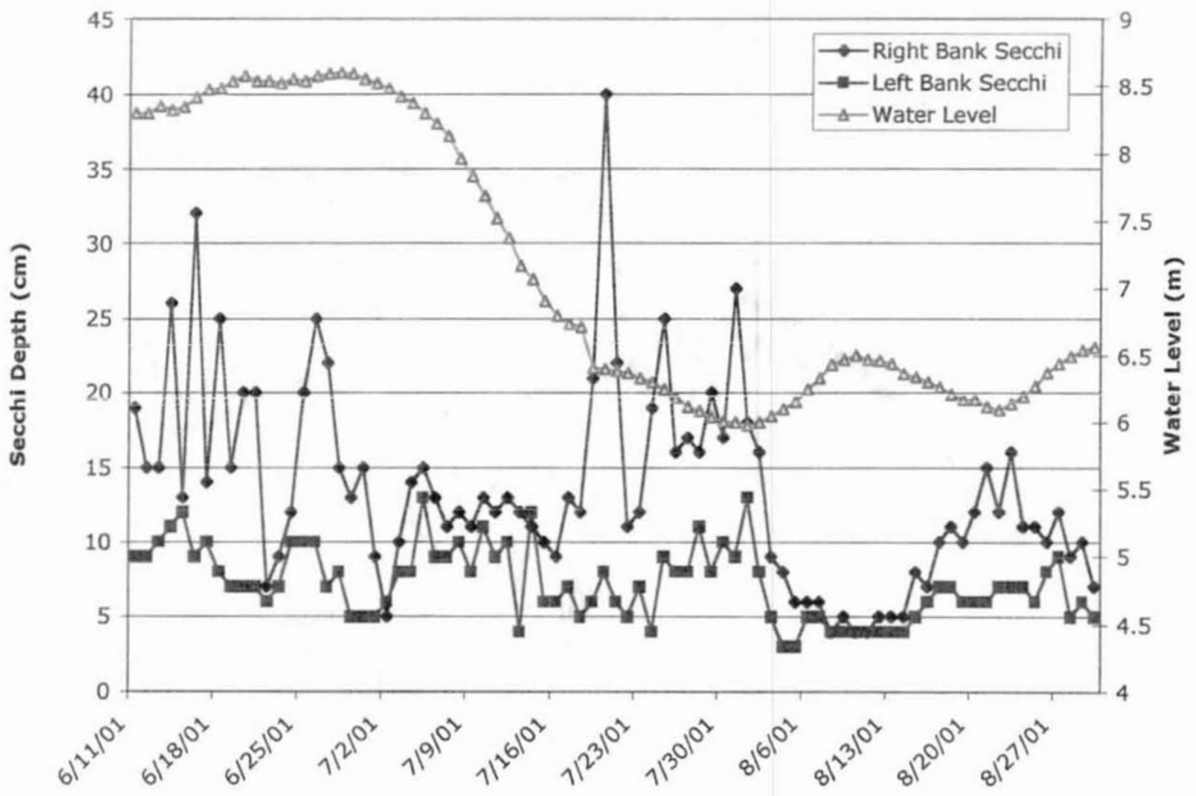


Figure 17. Comparison of daily right and left bank secchi measurements and water level at the Yukon River sonar project, 2001.

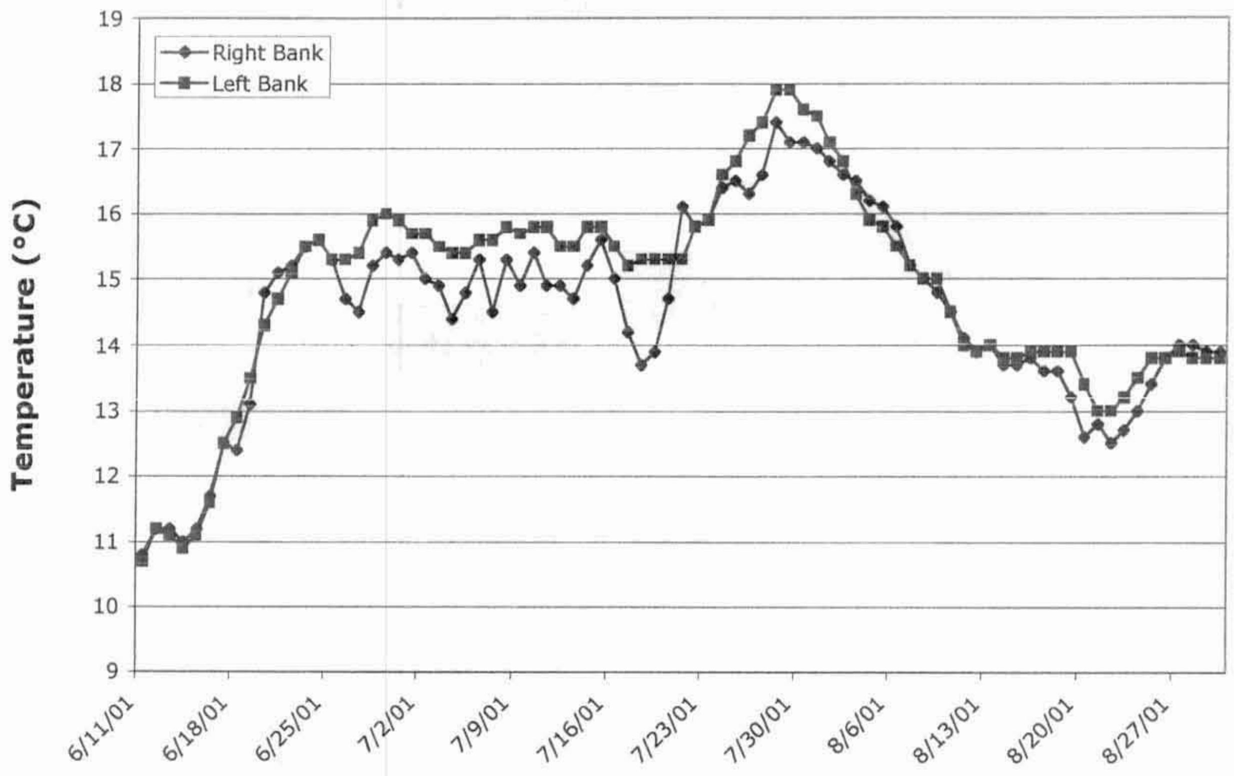
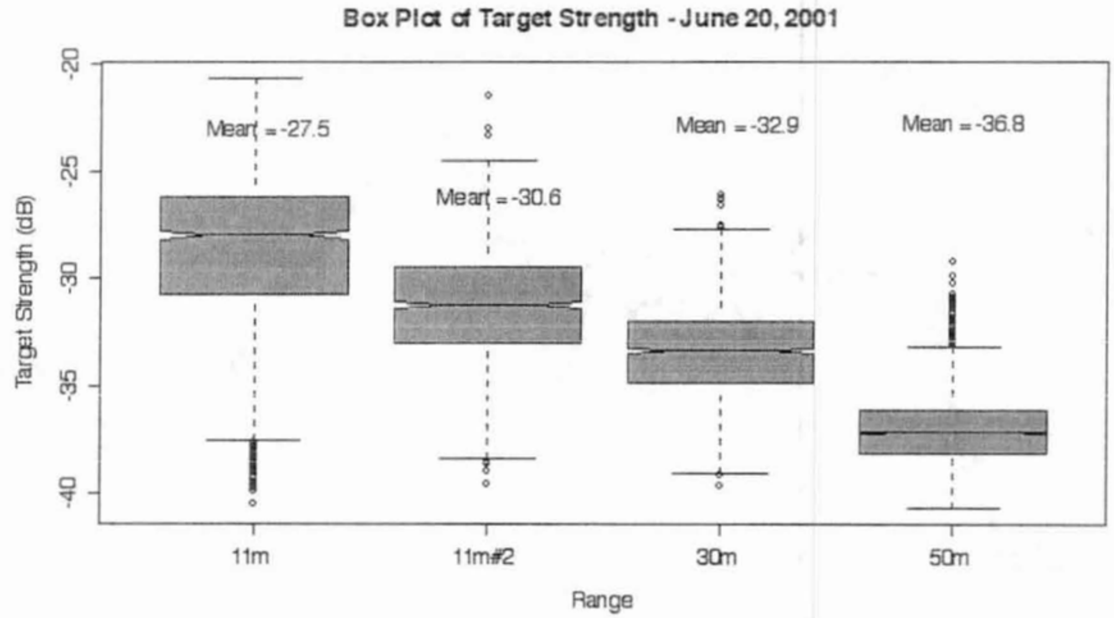


Figure 18. Daily right and left bank water temperatures at the Yukon River sonar project, 2001.



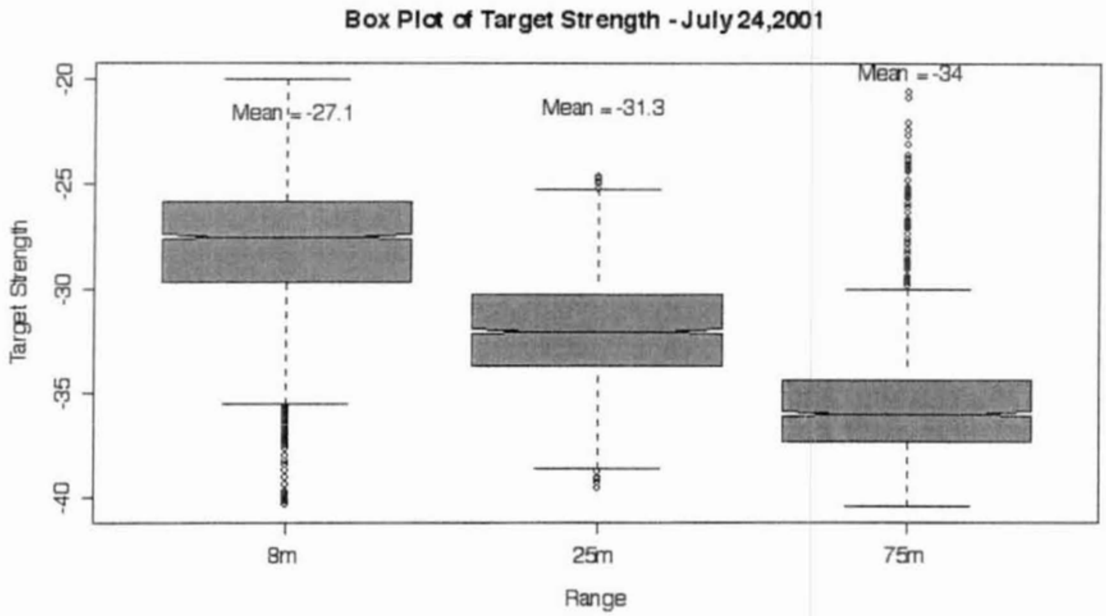


Figure 19. Box plots of target strength data collected on 20 June (top) and 24 July (bottom), Yukon River sonar project, 2001.

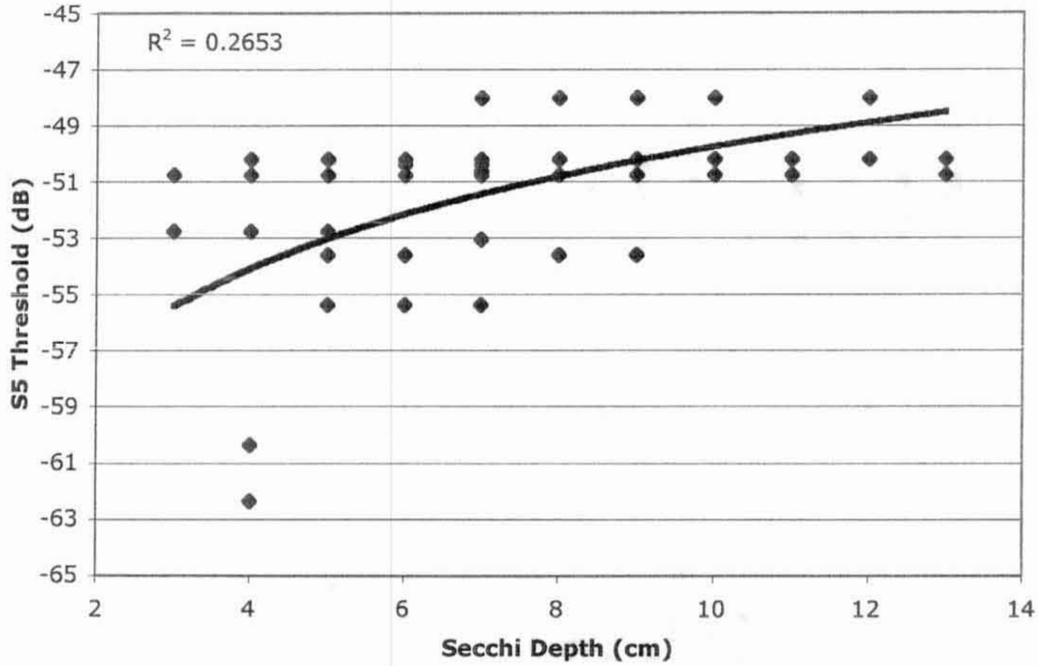


Figure 20. Comparison of daily left bank secchi readings and the stratum 5 thresholds used at the Yukon River sonar project, 2001.

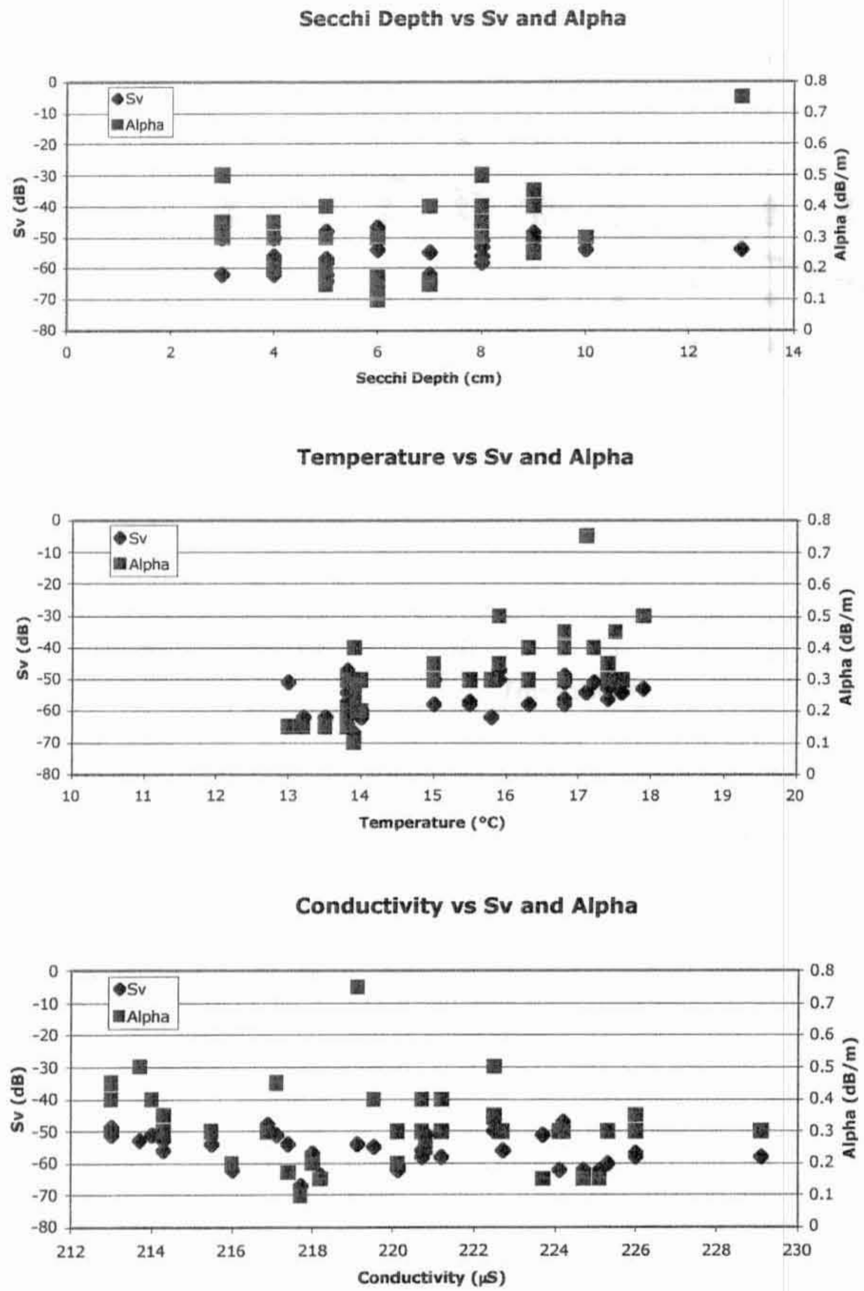


Figure 21. Scattering volume (Sv) and Alpha versus secchi depth (top), temperature (middle) and conductivity (bottom) at the Yukon River sonar project, 2001.

APPENDIX A. YUKON RIVER SONAR HOURLY PASSAGE RATE BY STRATUM, 2001.

Appendix A. Yukon River sonar hourly passage rate by stratum, 2001.

Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
1	06/11/01	1			104		
1	06/11/01	2	58.8	9			
1	06/11/01	3	111.3	12.7			
2	06/12/01	1	68.6	13.3	94		
2	06/12/01	2	70.9	3.4			
2	06/12/01	3	88.8	17.5			
3	06/13/01	1	62.1	8	79		
3	06/13/01	2	71	4.8			
3	06/13/01	3	64.9	9.6			
4	06/14/01	1	69.5	6.2	75		
4	06/14/01	2	60	8.7			
4	06/14/01	3	51.3	11.3			
5	06/15/01	1	58.6	15			
5	06/15/01	2	55.9	11.7			
5	06/15/01	3	63.3	17.1	61	8.4	1.9
5	06/16/01	1	139.8	20	37.7	18.6	2
5	06/16/01	2	96.3	14.7	63.2	78.6	4.1
5	06/16/01	3	143.1	32.4	109	17	2.7
6	06/17/01	1	189.3	26.3	257	26.4	8.6
6	06/17/01	2	86.6	31.8		17	0
6	06/17/01	3	289.8	89.3		37	0.2
6	06/18/01	1	270.7	74.7	365	41	10
6	06/18/01	2	239.3	40.2		44.5	15.6
6	06/18/01	3	310	80		62	3.1
7	06/19/01	1	256.7	81.1	487	66	0
7	06/19/01	2	362	55.2		104.5	11
7	06/19/01	3	483.3	114.7		15	1
8	06/20/01	1	489.5	70.5	647	31.5	6
8	06/20/01	2	469.9	107.3			
8	06/20/01	3	493.2	168.7		27.5	6.8
9	06/21/01	1	307.3	65.6	487	41.1	1.4
9	06/21/01	2	384.9	111.9		64.1	9.2
9	06/21/01	3	351.4	131.3		103.3	19.3
10	06/22/01	1	272.7	83.2	214.6	50.8	1.3
10	06/22/01	2	204.5	25.2	126	105	4.6
10	06/22/01	3	225	55.3	252	108.2	10.9
11	06/23/01	1	212	51	174.1	44	4.1
11	06/23/01	2	233.7	32.7	154.6	59	6.2
11	06/23/01	3	229.5	32	277	29	1

- Continued -

Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
12	06/24/01	1	290.1	68.1	153	36	2
12	06/24/01	2	213.8	22.8	167.6	96	4.1
12	06/24/01	3	321.1	112.6	261.5	203	1.5
13	06/25/01	1	182	50.7	147.3	151	0
13	06/25/01	2	312.3	19.3	433	80	7.1
13	06/25/01	3	294.7	62.7	703	119	15.5
14	06/26/01	1	201.1	42.4	614.4	80.7	10.2
14	06/26/01	2	504	50.5	636	68.3	5.2
14	06/26/01	3	489.2	108	571.1	145.9	15.5
15	06/27/01	1	581.7	99.5	768.2	140	6
15	06/27/01	2	565.9	91	1259	121.2	19.3
15	06/27/01	3	556.5	201.6	886.1	224.7	29.4
16	06/28/01	1	588.4	93.1	715.7	111.8	4.5
16	06/28/01	2	300.7	48.7	965.1	360	21.6
16	06/28/01	3	478	150	711	168	18
17	06/29/01	1	445.3	99.1			
17	06/29/01	2	463.1	96	689	117.7	15
17	06/29/01	3	502.4	80.2	846	249	22.8
18	06/30/01	1	428.1	45.5	489	169	45
18	06/30/01	2	408.4	99.3	548.1	109.7	7.2
18	06/30/01	3	433.7	125	510	120	18
18	07/01/01	1	410	112.7	505.5	94.1	4.1
18	07/01/01	2	254.7	52.5	345.8	194.2	20.7
18	07/01/01	3	354.7	52.6	559	122	17.9
19	07/02/01	1	290	62.7	249.2	64.1	14.2
19	07/02/01	2	197.7	55.1	228	137.3	12.2
19	07/02/01	3	165.2	89.3	241	126	35
20	07/03/01	1	91.4	23.9	263	83.6	13.2
20	07/03/01	2	193.3	20.2	249	130	2
20	07/03/01	3	149.7	24.1	338.6	97	14.5
20	07/04/01	1	155.7	13	231	87.3	14
20	07/04/01	2	141.3	19.3	281.3	80	11.2
20	07/04/01	3	135.2	51.3	304.1	95.2	23.4
21	07/05/01	1	121.5	22.8	232	48	6
21	07/05/01	2	151.3	19.7	365	66.1	3.6
21	07/05/01	3	104	42	512	46.2	10.2
22	07/06/01	1	143.9	44.3	420	43.7	3.1
22	07/06/01	2	91.4	23.3	414	74	10
22	07/06/01	3	104.5	46.5	417	43	16.6

- Continued -

Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
23	07/07/01	1	135	55.9	474	110	39
23	07/07/01	2	134	37	596.9	46.1	0
23	07/07/01	3	141.8	26.1	675	81.6	14.2
24	07/08/01	1	164.5	31.7	716	49.1	4.1
24	07/08/01	2	147.3	17	626.7	74.5	6.1
24	07/08/01	3	159.6	21.3	494	107	3
24	07/09/01	1	234.1	18.7	417.9	78.7	5.6
24	07/09/01	2	168.4	25.9	393	121	9.6
24	07/09/01	3	168.1	40	494.2	85.9	13.4
25	07/10/01	1	157.7	22.2	479	103.3	28
25	07/10/01	2	250.5	38.9	325.4	54.8	1
25	07/10/01	3	264.5	13.8	224.2	77.3	2.6
25	07/11/01	1	215.1	21.8	318	96	42
25	07/11/01	2	155.1	27.2	360	13	0
25	07/11/01	3	135.3	20	289.8	52.8	16.3
25	07/12/01	1	155.7	15.3	211	22.8	2.1
25	07/12/01	2	135.3	15.3	229.8	27.5	5.6
25	07/12/01	3	137.5	22.7	191	17.7	13.2
25	07/13/01	1	214.3	35.1	165	6.1	1.6
25	07/13/01	2	154.1	19.3	180	15.8	8
25	07/13/01	3	158.7	16	108.4	12	2
25	07/14/01	1	138.7	9.6	152	58	25
25	07/14/01	2	134.3	15.4	135.8	9.8	1.1
25	07/14/01	3	87	9.3	119	14.5	12
25	07/15/01	1	150.7	29.7	85.6	7.3	0
25	07/15/01	2	68.7	15.4	180	51.7	33.2
25	07/15/01	3	114	20	120	17.3	3.3
25	07/16/01	1	131.9	16.2	91	8.4	4.1
25	07/16/01	2	132.3	11.7	130	19	6
25	07/16/01	3	102	11.3	102.7	40.3	19.7
26	07/17/01	1	98.6	8.2	130	33.6	16.5
26	07/17/01	2	155.3	16	71	2	1
26	07/17/01	3	216.1	13.1	92.6	28.5	1
26	07/18/01	1	128.4	11.6	96	50	9
26	07/18/01	2	133.3	20.7	104.7	37	0
26	07/18/01	3	126	33.3	264.4	70	10.3
27	07/19/01	1	176	35.3	306	51.4	2.1
27	07/19/01	2	256.2	81.6	515	91	1
27	07/19/01	3	191.5	25.9	799	218.6	25

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
27	07/20/01	1	331	52	825	206.6	8
27	07/20/01	2	407	82.8	1175.8	246.9	21.7
27	07/20/01	3	317	122	1269	322	10.3
28	07/21/01	1	358.7	84.9	968	258	24
28	07/21/01	2	250.5	86	719	233.8	18.6
28	07/21/01	3	251.9	63.3	633.1	229.7	9.2
29	07/22/01	1	222.2	33.7	421	158.3	15.8
29	07/22/01	2	112.7	18.7	352.8	165.5	8.3
29	07/22/01	3	162.3	17	237	137	18
29	07/23/01	1	156.7	21.3	133	59	7.8
29	07/23/01	2	292.6	8.3			
29	07/23/01	3	212.3	20.9	151	94	9
30	07/24/01	1	155.6	5.3	167.6	106.6	4.1
30	07/24/01	2	268	10.7	141.4	74.7	12.4
30	07/24/01	3	185.3	22.2	140.3	47.8	2.1
30	07/25/01	1	186.1	15.2	100.7	36	0
30	07/25/01	2	405.7	58.6	253.2	98.6	18.6
30	07/25/01	3	221.3	51.2	313	138	25
31	07/26/01	1	200.7	57.3	328	94	2.6
31	07/26/01	2	294.7	84.3	382	174	7.6
31	07/26/01	3	264.4	55.3	480	204	11
32	07/27/01	1	212.7	53.3	316.3	123.9	6
32	07/27/01	2	196	55.3	377	220	30
32	07/27/01	3	304	20.9	377.3	193.4	2.1
33	07/28/01	1	176	14	207	131	16
33	07/28/01	2	127.2	11.3	240	148.5	2.7
33	07/28/01	3	113.4	23.3	130.2	130.3	6.1
33	07/29/01	1	56	14.7	143	81	13
33	07/29/01	2	59.3	12.3	130	104	0
33	07/29/01	3	94.9	16.7	127.5	59	7.1
33	07/30/01	1	74	26	69	63	2.5
33	07/30/01	2	178	12.1	171	59	10
33	07/30/01	3	77.1	14.7	174	121	26.9
33	07/31/01	1	48.8	7.7	134	62	6
33	07/31/01	2	116.6	12	122.1	105.5	5.5
33	07/31/01	3	153.2	15.5	162	122.1	21.4
33	08/01/01	1	69.4	13.5	52.1	28.5	4
33	08/01/01	2	158.2	20.9	137	88	13.2
33	08/01/01	3	110.8	12	83.8	42.4	4.1

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
34	08/02/01	1	104	20.7	116	50.7	1
34	08/02/01	2	152.7	20.7	363	161	10
34	08/02/01	3	394.4	89.7	491	288	6
35	08/03/01	1	244.7	43.3	358	215	15
35	08/03/01	2	210	32.7	421	513.1	6.2
35	08/03/01	3	188.9	35.7	372.6	210.5	18.6
35	08/04/01	1	119.3	25.3	326	149	6
35	08/04/01	2	226.8	30.7	390.5	165.8	9.2
35	08/04/01	3	318.7	48.8	537.9	293.5	22.2
36	08/05/01	1	344.7	48	587	245	12
36	08/05/01	2	262.7	45.8	758.1	314.2	1
36	08/05/01	3	282.5	50.5	640.6	348	1.1
37	08/06/01	1	311.2	31.4	457	273	3.5
37	08/06/01	2	335.3	40.4	457	237	3
37	08/06/01	3	234.7	45.3	575.2	261.4	6.1
37	08/07/01	1	215.3	22	336.6	138.3	3.2
37	08/07/01	2	288.7	28.6	259.3	209	0
37	08/07/01	3	242	30	246	179	0
38	08/08/01	1	168.8	22	195.3	99	0
38	08/08/01	2	313.1	43.2	266.6	136	4.1
38	08/08/01	3	351.7	47.6	288	115	2
39	08/09/01	1	588	86	380	121	0
39	08/09/01	2	628	87.3	505	217	9
39	08/09/01	3	781.3	114	590	258.9	6.2
40	08/10/01	1	556.8	146	570	297	12
40	08/10/01	2	472.7	133.4	613	318	6
40	08/10/01	3	530.1	119.3	386	224.2	2
40	08/11/01	1	281.8	64.7	404	238	12
40	08/11/01	2	352.5	59.1	379	319	9
40	08/11/01	3	325.1	66.9	321.6	194.2	10.6
41	08/12/01	1	275.7	68.2	264	237	12
41	08/12/01	2	325.1	49.3	258.9	244.2	5.3
41	08/12/01	3	316.4	36.8	216.4	152	9
42	08/13/01	1	265.3	40.7	244	188	12
42	08/13/01	2	271.3	58.6	279	295.9	21
42	08/13/01	3	248.6	52	186.1	297.9	10.3
43	08/14/01	1	222.3	55.2	199	195	19
43	08/14/01	2	269.3	40.7	204.8	280	23
43	08/14/01	3	260.7	62	348.8	281	12.4

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Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
44	08/15/01	1	252.7	79.3	283.7	226.8	3.2
44	08/15/01	2	399.5	71.9	373	257	14
44	08/15/01	3	352.7	69.4	386	334	35
45	08/16/01	1	263.2	103.3	371	289	29
45	08/16/01	2	370.7	78	356.8	270	18
45	08/16/01	3	279.1	67.3	341.1	292	
46	08/17/01	1	274.7	102	274.6	254.2	24.4
46	08/17/01	2	289	85.3	273.6	253.4	14.5
46	08/17/01	3	271.5	48	175	181	12
47	08/18/01	1	198.7	62.1	157.4	195	28.5
47	08/18/01	2	264.8	37.9	297	323	70
47	08/18/01	3	195.5	52.6	169	225	22.9
48	08/19/01	1	152.7	24.4	174	153	11
48	08/19/01	2	351.3	82	132.2	121	9.2
48	08/19/01	3	211	49.5	85	43	1.1
48	08/20/01	1	297.3	83.3			
48	08/20/01	2	438.3	71.3	146	53	1
48	08/20/01	3	207	48.1	218	124	7
49	08/21/01	1	191.6	42.1	178	143	8.4
49	08/21/01	2	231.4	40.7	285	175.9	36.6
49	08/21/01	3	235.3	51.9	201	141.1	30
49	08/22/01	1	138	44.5	129.3	107.6	10.3
49	08/22/01	2	141	54.2	220	144	33
49	08/22/01	3	112.1	36.7	181	161	26
50	08/23/01	1	148.7	23.3	200	143.4	14.2
50	08/23/01	2	244	30.7	281	111	10
50	08/23/01	3	213	43.3	275.6	99.3	3.1
51	08/24/01	1	196.5	53.6	331.5	158	6.7
51	08/24/01	2	270.3	44	267	112.9	2.1
51	08/24/01	3	233.9	55.4	196.5	131	9.3
51	08/25/01	1	242	47.3	171	133.8	5.1
51	08/25/01	2	134.7	29	315	172	20
51	08/25/01	3	165.3	38	219	127	1
52	08/26/01	1	203.9	28	193	122	6.9
52	08/26/01	2	269.7	36.7	181	121	11
52	08/26/01	3	234	28.7	240	151	16
53	08/27/01	1	176.7	38.4	116	76	9
53	08/27/01	2	292.3	14	111	97	16.3
53	08/27/01	3	130.2	22.7	90	50	6

- Continued -

Report Period	Date	Period	Right Bank Nearshore	Right Bank Offshore	Left Bank Nearshore	Left Bank Midshore	Left Bank Offshore
54	08/28/01	1	138.9	17.9	81	48	8
54	08/28/01	2	264.7	8.1	214	63	17
54	08/28/01	3	177.3	12	124	54	10
54	08/29/01	1	129.3	11	43.7	19.6	4.1
54	08/29/01	2	194.7	7.4	97	30	6.7
54	08/29/01	3	135.2	14.7	90	58	6.2
55	08/30/01	1	122	13	85	41	4
55	08/30/01	2	158.2	9.8	109	63.9	6.1
55	08/30/01	3	145.8	16.7	96	69	13
55	08/31/01	1	116.7	23.3	83	53	11
55	08/31/01	2	242	15	86.9	43	5.1
55	08/31/01	3	129.5	13.8	94	49.2	3.9